Module 1 - Introduction to Personal Computer Hardware

1.0 Introduction

1.0.1.1 Welcome

People prepare for work in the information technology fields by earning certifications, seeking formal education, and by experience through internships and jobs. In this chapter, you will learn about all the components that make up a PC starting with the case that houses all of the internal components. Computers, computer components, and computer peripherals all contain hazards that can cause severe injury. Therefore, this chapter begins with safety guidelines that you should follow to prevent electrical fires, injuries, and fatalities while working inside a computer. You will also learn about Electrostatic Discharge (ESD) and how it can damage computer equipment if it is not discharged properly.

This chapter will introduce you to all of the components that go inside of a computer case starting with the motherboard. You will learn about all the internal components that are connected to the motherboard, including the power supply, the central processing unit (CPU), random access memory (RAM), expansion cards, and storage drives. You will also learn about the connectors, ports, and cables that physically connect the devices to the motherboard.

It is important to not only learn about computer components but also build hands-on skills. In this chapter you will have a in which you will disassemble a computer so that you can become more familiar with all of the components and how they are connected.

1.1.1 What is in a Computer?

1.1.1.1 Video Explanation - What's in a Computer?

Hello everyone. Let's take a look at what's inside of a computer.

Now to start it off, computers have changed drastically. What we can see here, is this little computer can do everything we see on my desk right now. We can connect to speakers and monitor, keyboard and mouse and even a webcam and a microphone. They used to take a room, just full of mainframes, to do what this little single-board computer can do. Also our computers are drastically changing, because now we have integrated computers and smart watches and even health and fitness trackers. It's astounding where we're at now.

So let's talk about what a computer does. A computer's going to take input. And by taking input, it's then going to store it in memory. It'll be processed and then be provided as output.

So let's chat about it. We've got these input devices here. I've got a keyboard and a mouse. I've got a microphone. Then I've got output. I've got speakers. Here, I have my monitor. Also there's another input device sitting right here staring at me. It's my webcam. That's going to take in data as well. So let's change it up and talk about some of the other components in a computer.

So those components on the outside got to connect somewhere. So we can take a look at this, box. People call it a box. It's a computer case, it's a computer tower. Or you can just call it, the box. We take a look at the box, you can take a look at the front of our box.

And you'll find that we have USB ports, to plug in our components on the outside, like keyboard and mice. You got a headphone for speaker out. You got a microphone in port. You've got this optical drive, for those people who still use CDs. Which you never know.

Now besides the front of the box, you can take a look at the back of the box. And the back of our box here, we can see a variety of different items. We've got the power supply to plug in the computer case and power everything going on. We've got these adapter cards here, that gives us extra functionality. One here is for networking and internet. The other one's for display, to give us multiple monitors.

And besides all that, down below, we've got these connectors here, that hook to the system board. I've got some for the microphone. I've got something for a speaker. For external line in, to put those high-powered audio and send it into the computer system. I've got multiple display ports here, regarding VGA, DVI. Some cool ways to output to, again, monitors.

Now these thing aren't as powerful as this graphics card here. That graphics card there, well, that would be something like this. Something big and beefy to play your games. To do things such as virtual reality and 3D. You name it, that's where that goes. Now these graphics card ports here, it's built into the motherboard. Not as powerful.

Down below, I've got four USB ports to connect more external devices and components. And I also got a built in networking jack. Why two networking jacks? Because one might be built into the system board and another one might be awesome for gaming and high performance.

Let's take a look at the inside of this case and see what else we have going on here. Let's get inside the box. So we'll take off this side panel here and we'll get into the internals of our computer system. So we take a look at the inside of this computer system and one of the first things we see is this fan here. And this fan is sitting on top of these fins. And these fins have one job. To keep the CPU underneath cool. That CPU is going to be executing instructions and running programs. And that CPU's going to get really hot, really fast. That heat's going to go to these fins. And this fan here is going to cool down those fins.

Now what's that CPU doing? Well as our computer system takes an input, it's going to be taking in information. That information is going to be processed, through that CPU. And it's going to be stored in things like this hard-drive here, or right here, on these memory sticks.

So these memory sticks, they're called RAM. And these RAM sticks here, are going to temporarily store data so it can be executed faster, by our CPU. When we store data permanently, it'll be put on this hard-drive over here, which is a solid-state drive. An example of that, would be my solid-state drive, right here. These solid-state drives are going to retain data and be able to read and write data very fast.

Now besides that, we have some expansion cards here. And these are going to be our graphics card and that network card we saw earlier. These are in expansion slots, which gives us more functionality. It adds more to our system board.

Where's the system board? Well that system board is this entire motherboard down below. Which is attached into our computer case. This motherboard is full of different components and capacitors and circuitry. It allows our entire computer system to be able to be sending and receiving data.

At the top here, I got an optical drive. That optical drive, uses those old-style CD/DVD discs. Yup, that can temporarily store data, on a CD or DVD.

Up here, this is our power supply. This is providing power down to all the components within the system. Including the main board itself, that system board. This power supply will attach to your wall outlet and give you the power needed to run all of your components inside. Whether you have a small graphics card or you're dropping in the latest and greatest beefy ones, in order to run anything you want to throw at your system. Including gaming. Homework assignments as well as business and productivity.

So get started identifying what is inside of your computer and become an IT professional.

1.1.2 Electrical and ESD Safety

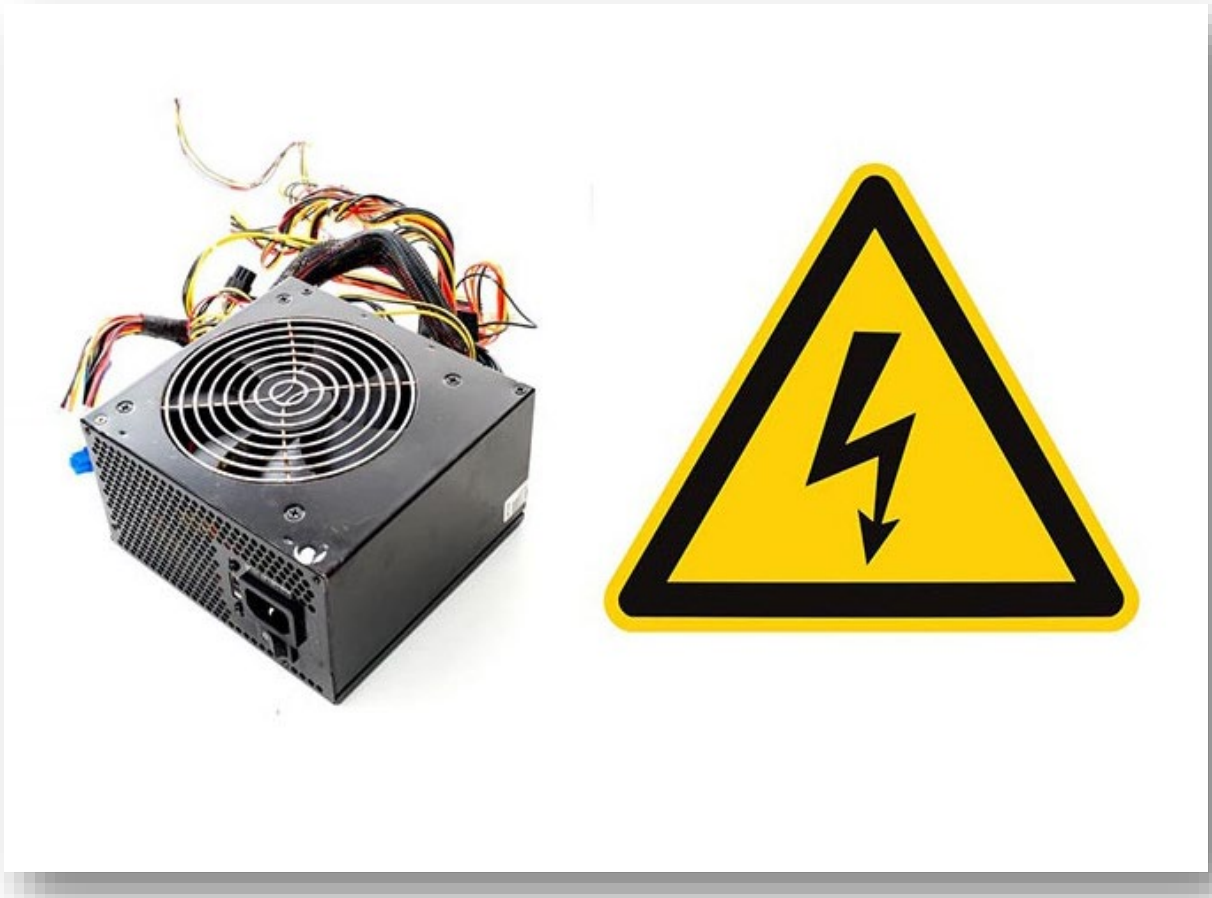
1.1.2.1 Electrical Safety

Follow electrical safety guidelines to prevent electrical fires, injuries, and fatalities.

Some printer parts, such as power supplies, contain high voltage. Check the printer manual for the location of high-voltage components. Some components retain a high voltage even after the printer is turned off.

Electrical devices have certain power requirements. For example, AC adapters are manufactured for specific laptops. Exchanging AC adapters with a different type of laptop or device may cause damage to both the AC adapter and the laptop.

Electric equipment must be grounded. If a fault causes metal parts of the equipment to become live with electrical current, the ground will provide a path of least resistance for the current to flow harmlessly away. Typically computer product connect to ground via the power plug. Large equipment such as server racks that house network devices must also be grounded.



1.1.2.2 ESD

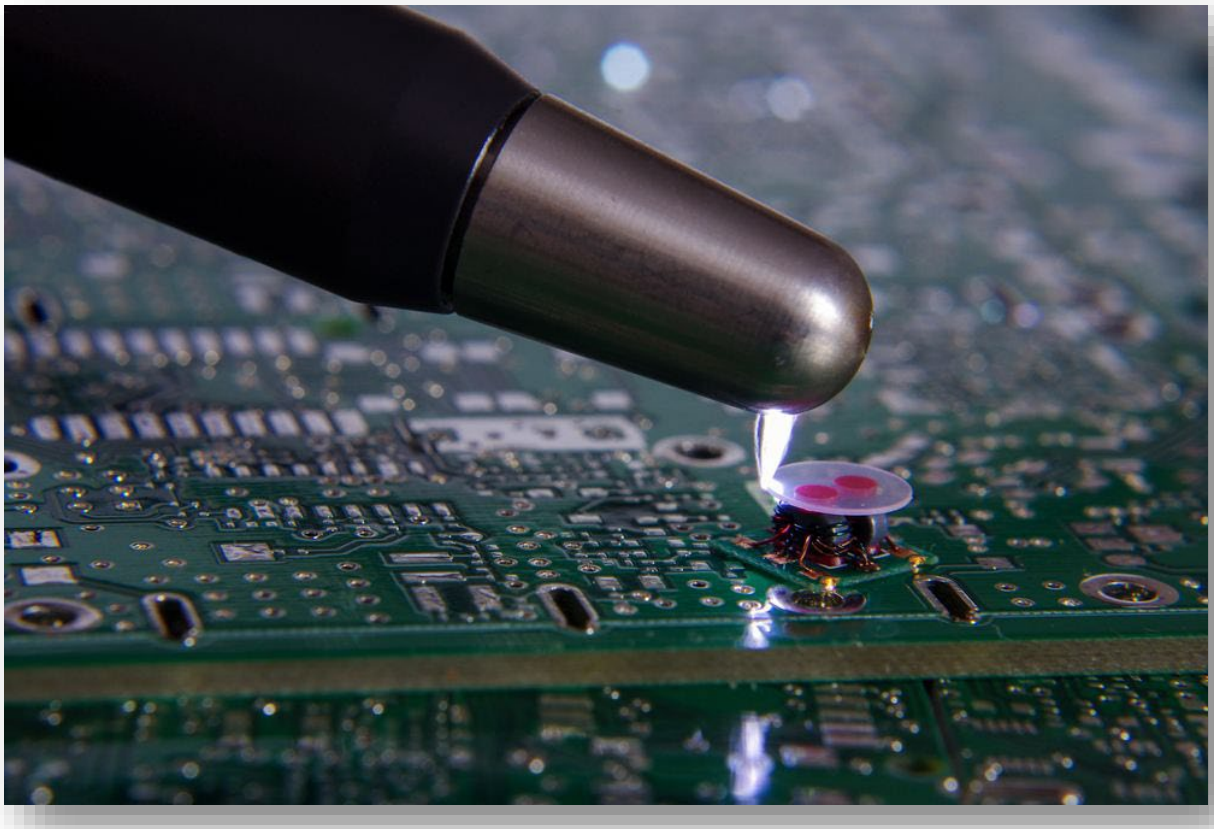
Electrostatic discharge (ESD) can occur when there is a buildup of an electric charge (static electricity) that exists on a surface which comes into contact with another, differently charged surface. ESD can cause damage to computer equipment if not discharged properly. Follow proper handling guidelines, be aware of environmental issues, and use equipment that stabilizes power to prevent equipment damage and data loss.

At least 3,000 volts of static electricity must build up before a person can feel ESD. For example, static electricity can build up on you as you walk across a carpeted floor. When you touch another person, you both receive a shock. If the discharge causes pain or makes a noise, the charge was probably above 10,000 volts. By comparison, less than 30 volts of static electricity can damage a computer component. Static buildup can be discharged by touching a grounded object prior to touching any electronic equipment. This is known as self-grounding

ESD can cause permanent damage to electrical components. Follow these recommendations to help prevent ESD damage:

- Keep all components in antistatic bags until you are ready to install them.
- Use grounded mats on workbenches.
- Use grounded floor mats in work areas.

- Use antistatic wrist straps when working inside computers.



1.2.1 Case and power supplies

1.2.1.1 Cases

Slide show. Select the next button to progress.

The case of a desktop computer houses the internal components such as the power supply, motherboard, central processing unit (CPU), memory, disk drives, and assorted adapter cards. Cases are typically made of plastic, steel, or aluminum and provide the framework to support, protect, and cool the internal components. A device form factor refers to its physical design and look. Desktop computers are available in a variety of form factors including:

- Horizontal case
- Full-Size Tower
- Compact Tower
- All-in-one

This list is not exhaustive, as many case manufacturers have their own naming conventions. These may include super tower, full tower, mid tower, mini tower, cube case, and more. Computer components tend to generate a lot of heat; therefore, computer cases contain fans that move air through the case. As the air passes warm components, it absorbs heat and then exits the case. This process keeps the computer components from overheating. Cases are also

designed to protect against static electricity damage. The computer’s internal components are grounded via attachment to the case.

Note: Computer cases are also referred to as the computer chassis, cabinet, tower, housing, or simply box.

Horizontal case

This computer case is horizontally oriented on the user's desk with the monitor often positioned on top and was popular with early computer systems. This form factor is often used for home theater PCs (HTPCs).

Full-Size Tower

This vertically-oriented case is typically located on the floor under, or beside, a desk or table. It provides room for expansion to accommodate additional components such as disk drives, adapter cards, and more.

Compact Tower

This is a smaller version of the full-size tower and is commonly found in the corporate environment. It may also be called a mini-tower or small form factor (SFF) model. It can be located on the user's desk or on the floor. It provides limited room for expansion.

All-in-one

All of the computer system components are integrated into the display. They often include touch-screen input and built-in microphone and speakers. Depending on the model, all-in-one computers offer little to no expansion capabilities. The power supply is often external to the computer.

1.2.1.2 Power Supplies

Electricity from wall outlets is provided in alternating current (AC). However, all components inside a computer require direct current (DC) power. To obtain DC power, computers use a power supply, as shown here, to convert AC power into a lower voltage DC power.

The following describes the various computer desktop power supply form factors that have evolved over time:

- **Advanced Technology (AT)** – This is the original power supply for legacy computer systems now considered obsolete.
- **AT Extended (ATX)** – This is the updated version of the AT but still considered to be obsolete.
- **ATX12V** – This is the most common power supply on the market today. It includes a second motherboard connector to provide dedicated power to the CPU. There are several versions of ATX12V available.

- **EPS12V** – This was originally designed for network servers but is now commonly used in high-end desktop models.

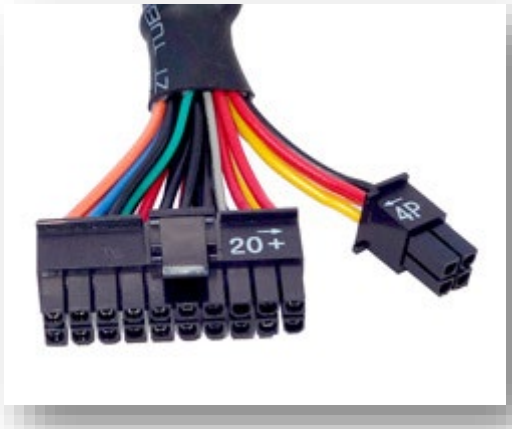
1.2.1.3 Connectors

Connectors

A power supply includes several different connectors, as shown here. These connectors are used to power various internal components such as the motherboard and disk drives. The connectors are “keyed” which means that they are designed to be inserted in only one orientation.

A 20-pin or 24-pin slotted connector

• Connects to the motherboard
• The 24-pin connector has two rows of 12 pins each
• The 20-pin connector has two rows of 10 pins each



SATA keyed connector

• Connects disk drives
• Connector is wider and thinner than a Molex connector

Molex keyed connector

• Connects hard drives, optical drives, or other devices

Berg keyed connector

• Connect to legacy floppy drives
• Smaller than a Molex connector

4-pin to 8-pin auxiliary power connector

• Connector has two rows of two to four pins and supplies power to different areas of the motherboard
• The auxiliary power connector is the same shape as the main power connector but smaller

6/8-pin PCIe power connector

• Connector has two rows of three to four pins and supplies power to internal components

1.2.1.4 Power Supply Voltage

The different connectors also provide different voltages. The most common voltages supplied are 3.3 volts, 5 volts, and 12 volts. The 3.3 volt and 5 volt supplies are typically used by digital circuits, while the 12 volt supply is used to run motors in disk drives and fans.

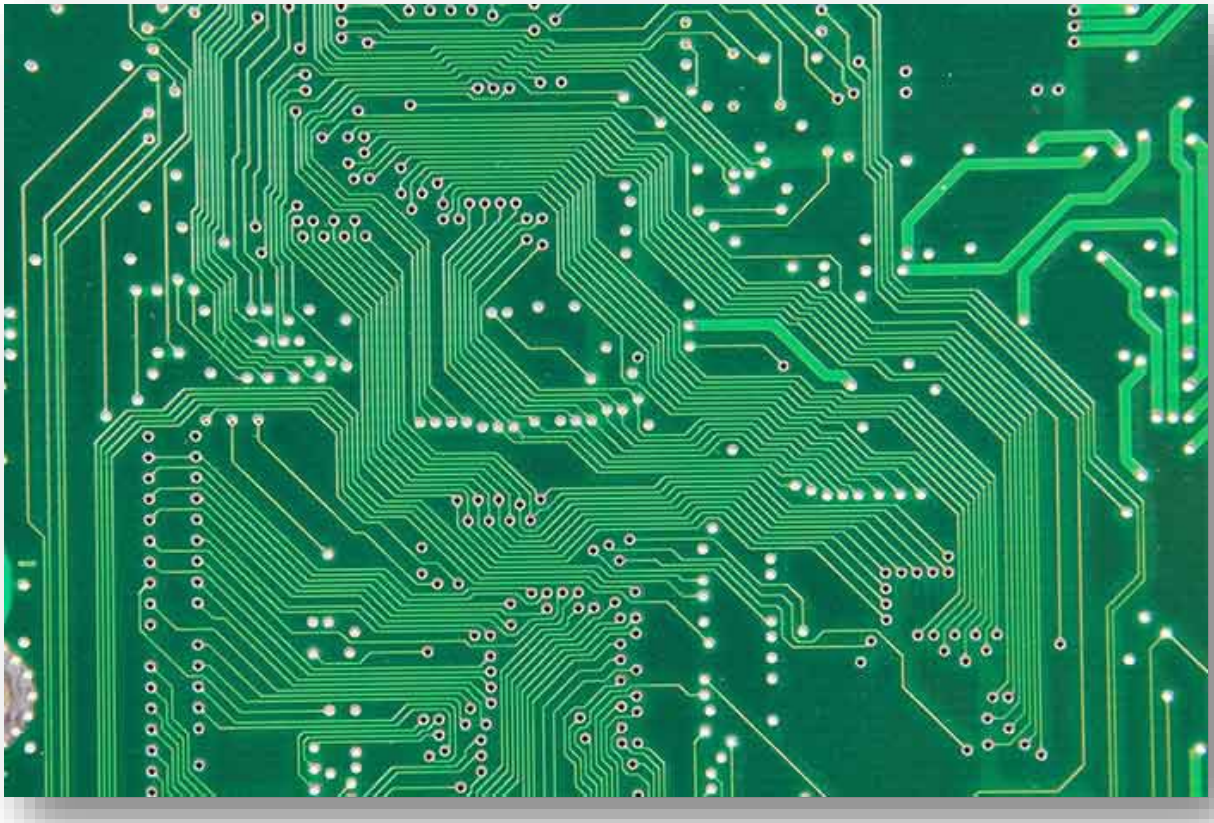
Power supplies can also be single rail, dual rail, or multi rail. A rail is the printed circuit board (PCB) inside the power supply to which the external cables are connected. A single rail has all of the connectors connected to the same PCB while a multi rail PCB has separate PCBs for each connector.

A computer can tolerate slight fluctuations in power, but a significant deviation can cause the power supply to fail.

1.2.2 Motherboards

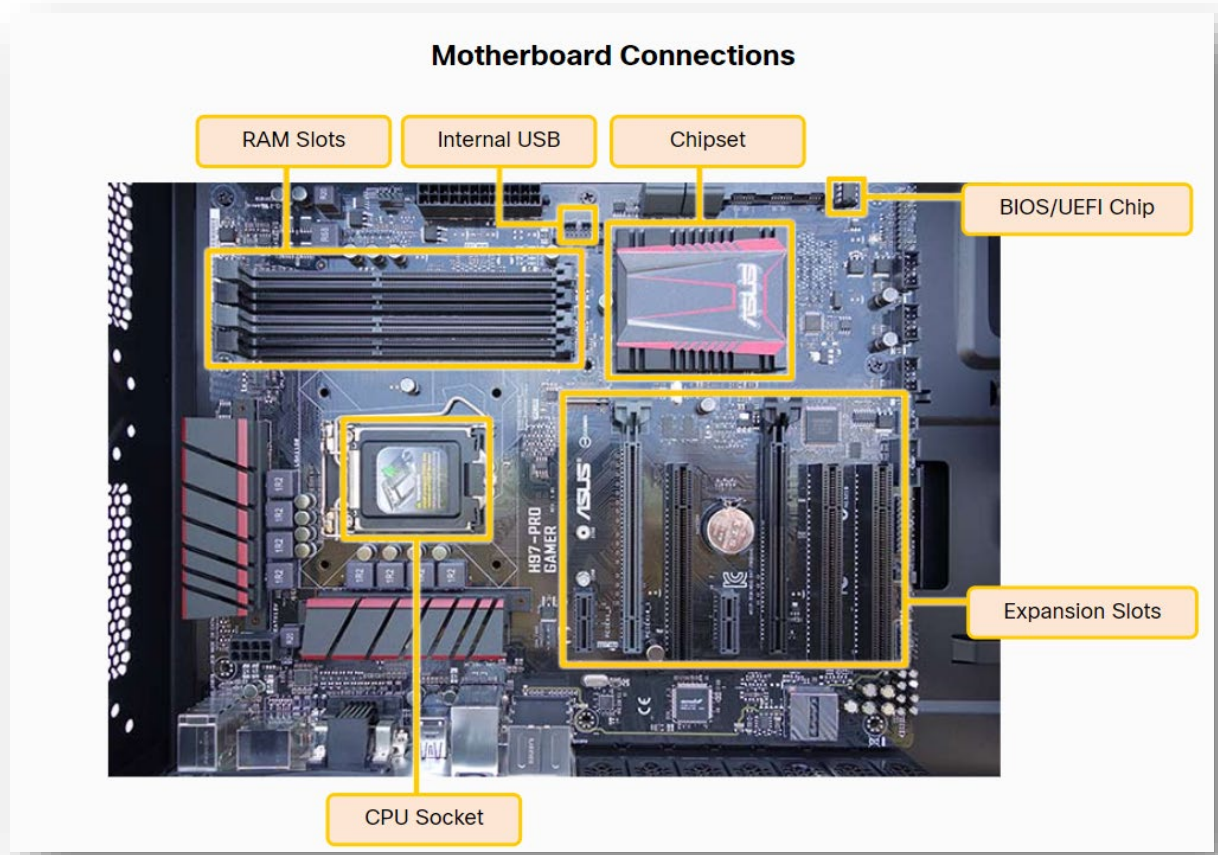
1.2.2.1 Motherboards

The motherboard, also known as the system board or the main board, is the backbone of the computer. As shown in the figure, a motherboard is a printed circuit board (PCB) that contains buses, or electrical pathways, that interconnect electronic components. These components may be soldered directly to the motherboard, or added using sockets, expansion slots, and ports.



1.2.2.2 Motherboard Components

These are some connections on the motherboard where computer components can be added, as shown in the figure of a motherboard below.



The connections labeled in the figure are the following:

- **Central Processing Unit (CPU)** - This is considered the brain of the computer.
- **Random Access Memory (RAM)** - This is a temporary location to store data and applications
- **Expansion slots** - These provide locations to connect additional components.
- **Chipset** - This consists of the integrated circuits on the motherboard that control how system hardware interacts with the CPU and motherboard. It also establishes how much memory can be added to a motherboard and the type of connectors on the motherboard.
- **Basic input/output system (BIOS) chip and Unified Extensible Firmware Interface (UEFI) chip** - BIOS is used to help boot the computer and manage the flow of data between the hard drive, video card, keyboard, mouse, and more. In modern computers BIOS has been replaced by UEFI. UEFI specifies a different firmware for boot and runtime services. Firmware is programming that allows a computer operating system to control the hardware.

SATA

SATA, or Serial Advanced Technology Attachment (ATA), is a disk drive interface used for connecting optical drives, hard drives, and solid-state drives to the motherboard. SATA supports hot swapping, which is the ability to replace devices without powering off the computer.

IDE

Integrated Drive Electronics (IDE) is an older standard interface for connecting disk drives to the motherboard. IDE uses a 40-pin connector. Each IDE interface supports a maximum of two devices.

Internal USB

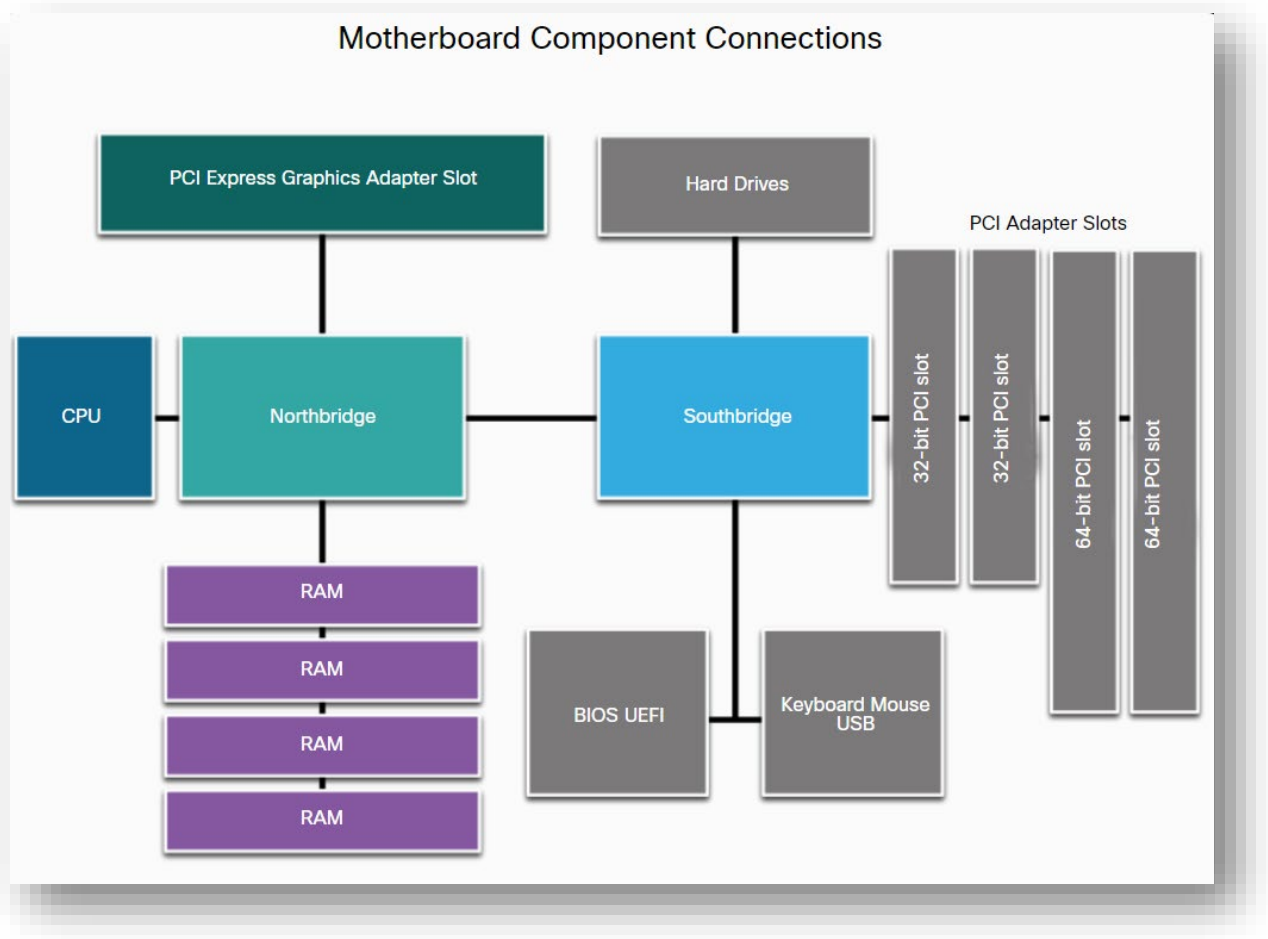
A 19-pin connector is used to connect the external USB 3 ports on the computer case to the motherboard. USB 1.1 and USB 2 connectors have 9 pins.

1.2.2.3 Motherboard Chipset

The figure illustrates how a motherboard connects various components.

Most chipsets consist of the following two types:

- **Northbridge** – Controls high speed access to the RAM and video card. It also controls the speed at which the CPU communicates with all of the other components in the computer. Video capability is sometimes integrated into the Northbridge.
- **Southbridge** – Allows the CPU to communicate with slower speed devices including hard drives, Universal Serial Bus (USB) ports, and expansion slots



1.2.2.4 Motherboard Form Factors

The form factor of motherboards pertains to the size and shape of the board. It also describes the physical layout of the different components and devices on the motherboard.

There have been many variations of motherboards developed over the years. There are three common motherboard form factors:

- **Advanced Technology eXtended (ATX)** - This is the most common motherboard form factor. The ATX case accommodates the integrated I/O ports on the standard ATX motherboard. The ATX power supply connects to the motherboard via a single 20-pin connector.
- **Micro-ATX** – This is a smaller form factor that is designed to be backward-compatible with ATX. Micro-ATX boards often use the same Northbridge and Southbridge chipsets and power connectors as full-size ATX boards and therefore can use many of the same components. Generally, Micro-ATX boards can fit in standard ATX cases. However, Micro-ATX motherboards are much smaller than ATX motherboards and have fewer expansion slots.
- **ITX** - The ITX form factor has gained in popularity because of its very small size. There are many types of ITX motherboards; however, Mini-ITX is one of the most popular. The Mini-ITX form factor uses very little power, so fans are not needed to

keep it cool. A Mini-ITX motherboard has only one PCI slot for expansion cards. A computer based on a Mini-ITX form factor can be used in places where it is inconvenient to have a large or noisy computer.

The table highlights these and other form factor variations.

Note: It is important to distinguish between form factors. The choice of motherboard form factor determines how individual components attach to it, the type of power supply required, and the shape of the computer case. Some manufacturers also have proprietary form factors based on the ATX design. This causes some motherboards, power supplies, and other components to be incompatible with standard ATX cases.

Motherboard Form Factors

Form Factor	Description
ATX	• Advanced Technology eXtended • Most popular form factor • 12 in X 9.6 in (30.5 cm X 24.4 cm)
Micro-ATX	• Smaller footprint than the ATX • Popular in desktop and small form factor computers • 9.6 in X 9.6 in (24.4 cm X 24.4 cm)
Mini-ITX	• Designed for small devices such as thin clients and set-top boxes • 6.7in X 6.7 in (17cm X 17 cm)
ITX	• Comparable form factor to Micro-ATX • 8.5 in X 7.5 in (21.5 cm X 19.1 cm)

1.2.3 CPUs and Cooling Systems

1.2.3.1 What is a CPU?

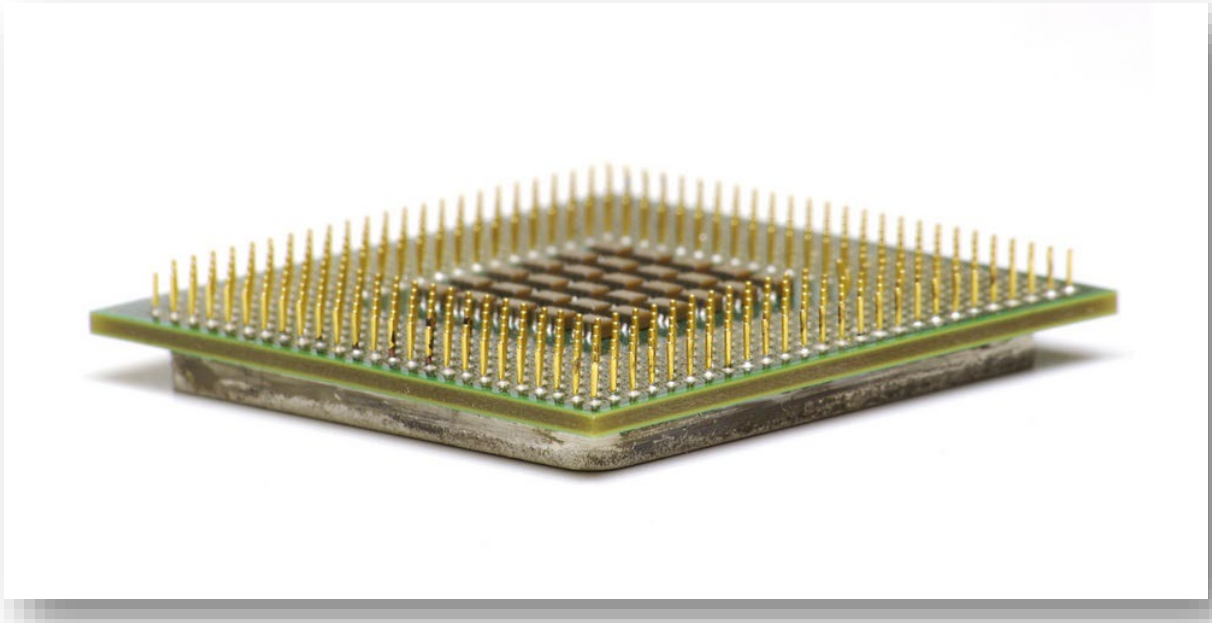
The central processing unit (CPU) is responsible for interpreting and executing commands. It handles instructions from the computer's other hardware, such as a keyboard, and software. The CPU interprets the instructions and outputs the information to the monitor or performs the requested tasks.

The CPU is a small microchip that resides within a CPU package. The CPU package is often referred to as the CPU. CPU packages come in different form factors, each style requiring a particular socket on the motherboard. Common CPU manufacturers include Intel and AMD.

The CPU socket is the connection between the motherboard and the processor. Modern CPU sockets and processor packages are built around the following architectures:

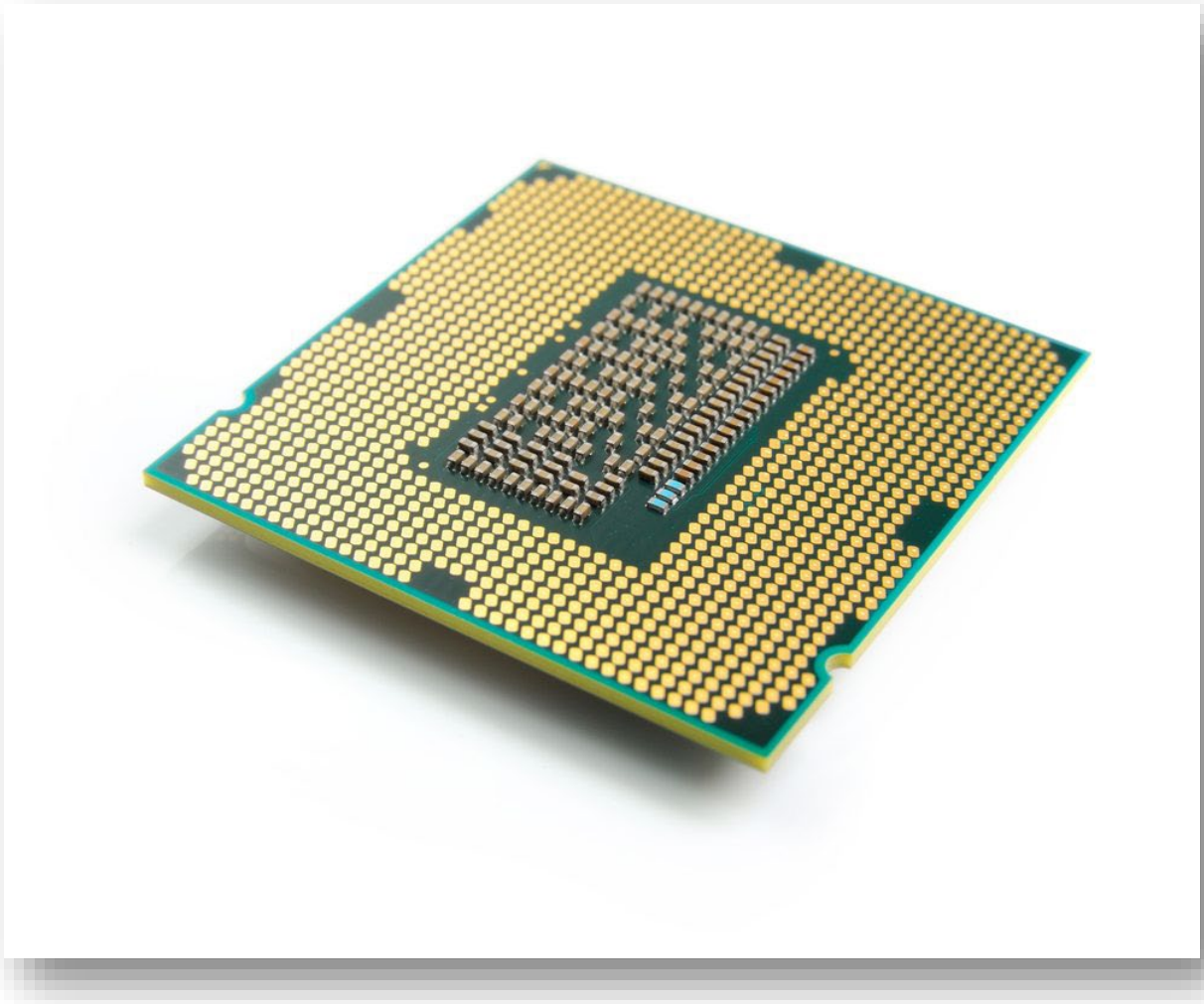
Pin Grid Array (PGA)

In PGA architecture (shown below), the pins are on the underside of the processor package and is inserted into the motherboard CPU socket using zero insertion force (ZIF). ZIF refers to the amount of force needed to install a CPU into the motherboard socket or slot.



Land Grid Array (LGA)

In an LGA architecture (shown below), the pins are in the socket instead of on the processor.



1.2.3.2 Cooling Systems

The flow of current between electronic components generates heat. Computer components perform better when kept cool. If the heat is not removed, the computer may run more slowly. If too much heat builds up, the computer could crash, or components can be damaged. Therefore, it is imperative that computers be kept cool.

Computers are kept cool using active and passive cooling solutions. Active solutions require power while passive solutions do not. Passive solutions for cooling usually involve reducing

the speed at which a component is operating or adding heat sinks to computer chips. A case fan is considered as active cooling. The figure shows examples of passive and active cooling solutions.

Heat Sink (Passive Cooling)

Case Fan (Active Cooling)

1.2.4 Memory

1.2.4.1 Types of Memory

A computer might use different types of memory chips, as shown in the figure. However, all memory chips store data in the form of bytes. A byte is a grouping of digital information and represents information such as letters, numbers, and symbols. Specifically, a byte is a block of eight bits stored as either 0 or 1 in the memory chip.

Read-Only Memory

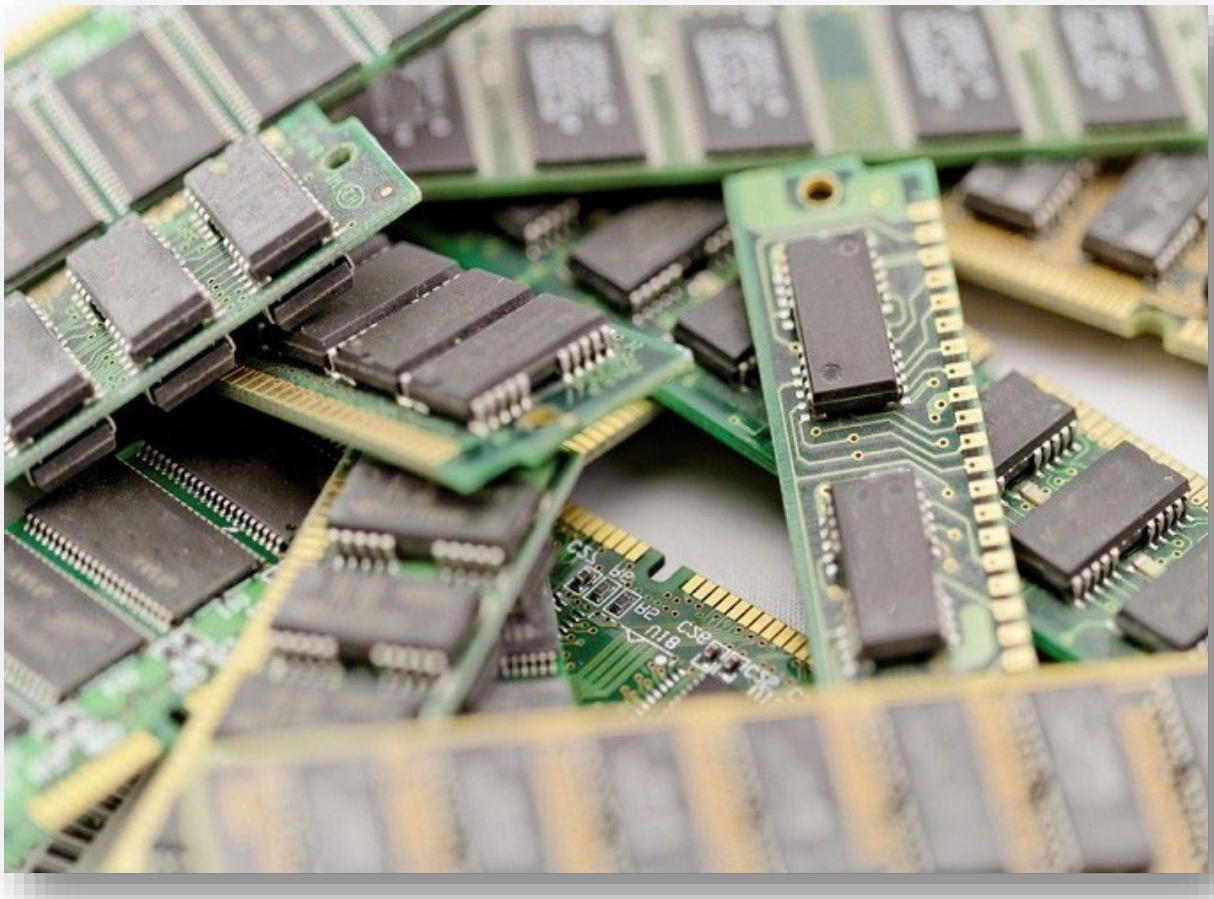
An essential computer chip is the read-only memory (ROM) chip. ROM chips are located on the motherboard and other circuit boards and contain instructions that can be directly accessed by a CPU. The instructions stored in ROM include basic operation instructions such as booting the computer and loading the operating system.

ROM is nonvolatile which means that the contents are not erased when the computer is powered off.

Random Access Memory

RAM is the temporary working storage for data and programs that are being accessed by the CPU. Unlike ROM, RAM is volatile memory, which means that the contents are erased every time the computer is powered off.

Adding more RAM in a computer enhances the system performance. For instance, more RAM increases the memory capacity of the computer to hold and process programs and files. With less RAM, a computer must swap data between RAM and the much slower hard drive. The maximum amount of RAM that can be installed is limited by the motherboard.



1.2.4.2 Types of ROM

ROM

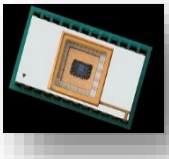
Read-only memory chips. Information is written to a ROM chip when it is manufactured. A ROM chip that cannot be erased or re-written is now obsolete. The term ROM still tends to be used generically for any read-only memory chip type.

PROM

Information on a programmable read-only memory chip is written after it is manufactured. PROMs are manufactured blank and then can be programmed by a PROM programmer when needed. Generally, these chips cannot be erased and can only be programmed once.

EPROM

Erasable programmable read-only memory is non-volatile but can be erased by exposing it to strong ultraviolet light. EPROMs usually have a transparent quartz window on the top of the chip. Constant erasing and reprogramming could ultimately render the chip useless.



EEPROM

Information is written to an electrically erasable programmable read-only memory chip after it is manufactured and without removing it from the device. EEPROM chips are also called Flash ROMs since its contents can be "flashed" for deletion. EEPROMs are often used to store a computer system's BIOS.

1.2.4.3 Types of RAM

Dynamic RAM

- Older technology, popular until the mid-1990s
- Used for main memory

- DRAM gradually discharges energy so it must be constantly refreshed with pulses of electricity in order to maintain the stored data in the chip

Static RAM

- Requires constant power to function
- Often used for cache memory
- Uses lower power consumption
- Much faster than DRAM
- More expensive than DRAM

SD RAM

- DRAM that operates in synchronization with the memory bus
- Able to process overlapping instructions in parallel – e.g. It can process a read before a write has been completed
- Higher transfer rates

Double Data Rate Synchronous Dynamic RAM

- DDR SDRAM transfers data twice as fast as SDRAM
- Able to support two writes and two reads per CPU clock cycle
- Connector has 184 pins and a single notch
- Uses lower standard voltage (2.5 V)
- Family: DDR2, DDR3, DDR4

DDR2 Synchronous RAM

- DDR2 SDRAM also transfers data twice as fast as SDRAM
- Runs at higher clock speeds than DDR (553 MHz vs. DDR at 200 MHz)
- Improves performance by decreasing noise and crosstalk between signal wires
- Connector has 240 pins
- Uses lower standard voltage (1.8 V)

DDR3 Synchronous RAM

- DDR3 SDRAM expands memory bandwidth by doubling the clock rate of DDR2
- Consumes less power than DDR2 (1.5 V)
- Generates less heat
- Runs at higher clock speeds (up to 800 MHz)
- Connector has 240 pins

DDR4 Synchronous RAM

- DDR4 SDRAM quadruples DDR3 maximum storage capacity
- Consumes less power than DDR3 (1.2 V)
- Runs at higher clock speeds (up to 1600 MHz)
- Connector has 288 pins

- Available with advanced error correction features such as error-correcting code memory (ECC memory) to detect multiple bit errors.

GDDR Synchronous Dynamic RAM

- The “G” stands for Graphics
- RAM specifically designed for video graphics
- Used in conjunction with a dedicated GPU
- Family: GDDR, GDDR2, GDDR3, GDDR4, GDDR5
- Each family member improves performance
- Each family member lowers power consumption
- GDDR SDRAM processes massive amounts of data but not necessarily at the fastest speeds

DDR5

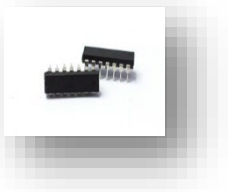
- More than double the speed of the fastest DDR4 modules.
- DDR5 quadruples DDR4 maximum storage capacity
- Slightly lower power consumption than DDR4 (1.1 V)
- Connector has 288 pins but a different pattern than DDR4, so they are not compatible
- Maximum module size is 128 GB

1.2.4.4 Memory Modules

Early computers had RAM installed on the motherboard as individual chips. The individual memory chips, called dual inline package (DIP) chips, were difficult to install and often became loose. To solve this problem, designers soldered the memory chips to a circuit board to create a memory module which would then be placed into a memory slot on the motherboard.

DIP

Dual Inline Package is an individual memory chip. A DIP has dual rows of pins used to attach it to the motherboard.

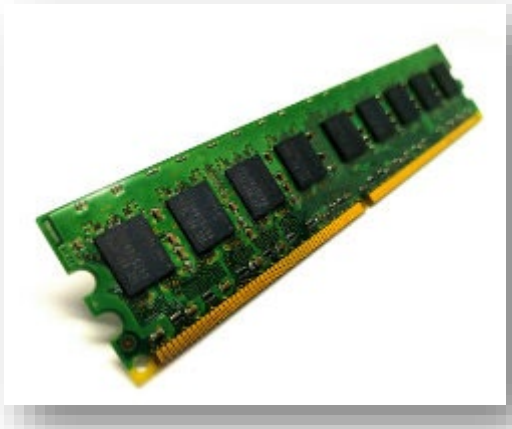


SIMM

Single Inline Memory Module is a small circuit board that holds several memory chips. SIMMs have 30-pin or 72-pin configurations.

DIMM Memory

Dual Inline Memory Module is a circuit board that holds SDRAM, DDR SDRAM, DDR2 SDRAM, DDR3 SDRAM, and DDR4 SDRAM chips. There are 168-pin SDRAM DIMMs, 184-pin DDR DIMMs, 240-pin DDR2 and DDR3 DIMMs, and 288-pin DDR4 DIMMs.



SODIMM

Small Outline DIMM has a 72-pin and 100-pin configurations for support of 32-bit transfers or a 144-pin, 200-pin, 204-pin, and 260-pin configurations for support of 64-bit transfers. This smaller, more condensed version of DIMM provides random access data storage that is ideal for use in laptops, printers, and other devices where conserving space is desirable.

Single-Sided, Double-Sided, and Multi-channel

Memory modules can be single-sided or double-sided. Single-sided memory modules contain RAM on only one side of the module. Double-sided memory modules contain RAM on both sides.

The speed of memory has a direct impact on how much data a processor can process in a given period of time. As processor speed increases, memory speed must also increase. Memory throughput has also been increased through multichannel technology. Standard RAM is single channel, meaning that all of the RAM slots are addressed at the same time. Dual channel RAM adds a second channel to be able to access a second module at the same time.
Triple channel technology provides another channel so that three modules can be accessed at the same time. Quadruple channel adds another channel to the memory controller for even higher bandwidth. To use triple and quadruple channel memory controllers for the most bandwidth, the chipset architecture must support it and will only be able to use as many channels that have memory slots populated. In many cases, memory slots can only be populated in a certain order in order to ensure all memory channels are used.

Cache Memory

A tabbed content container. Content can be text, graphic or both.
The fastest memory is typically static RAM (SRAM) which is cache memory for storing the most recently used data and instructions by the CPU. SRAM provides the processor with faster access to the data than retrieving it from the slower dynamic RAM (DRAM), or main memory.

L1

L1 cache is internal cache and is integrated into the CPU. A CPU can have various models each with a different amount of L1 cache.

L2

L2 cache is external cache and was originally mounted on the motherboard near the CPU. L2 cache is now integrated into the CPU.

L3

L3 cache is used on some high-end workstations and server CPUs.

Memory Errors

Memory errors occur when the data is not stored correctly in the chips. The computer uses different methods to detect and correct data errors in memory.

Nonparity

Nonparity memory does not check for errors in memory. Nonparity RAM is the most common RAM used for home and business workstations.

Parity

Parity memory contains eight bits for data and one bit for error checking. The error-checking bit is called a parity bit.

ECC

Error Correction Code memory can detect multiple bit errors in memory and correct single bit errors in memory. On servers used for financial or data analytics, ECC memory modules may be required.

Adapter Cards and Expansion Slots

1.2.5.1 Adapter Cards

A tabbed content container. Content can be text, graphic or both.
Adapter cards increase the functionality of a computer by adding controllers for specific devices or by replacing malfunctioning ports.
There are a variety of adapter cards available that are used to expand and customize the capability of a computer.

Sound Adapter

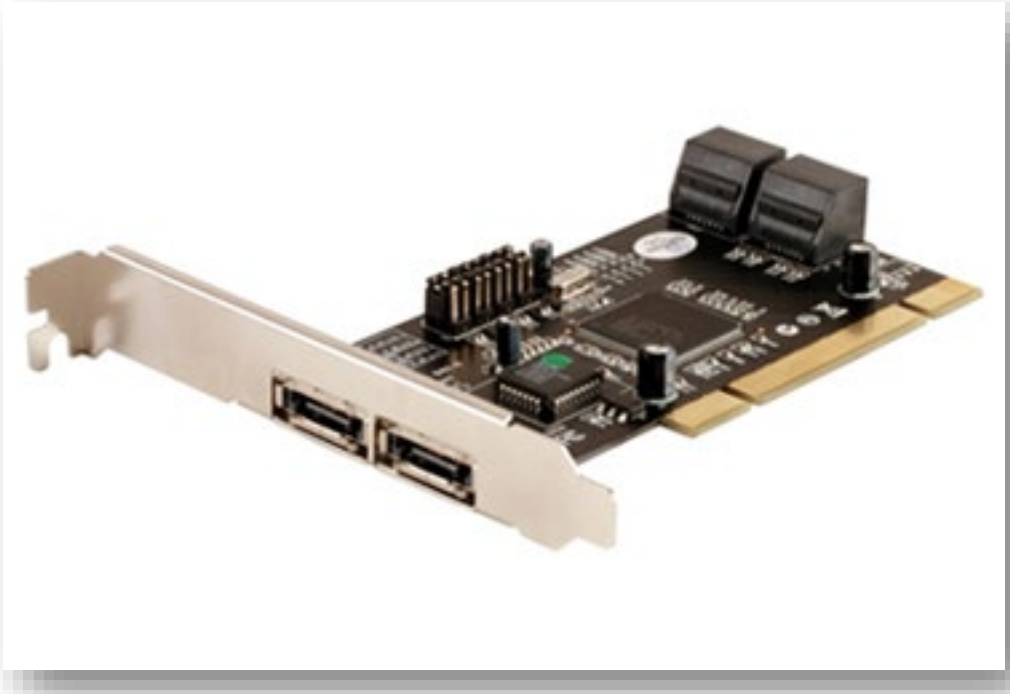
Sound adapters provide audio capability.

Network Interface Card (NIC)

A NIC connects a computer to a network using a network cable.

eSATA cards

Adds additional internal and external SATA ports to a computer through a single PCI Express slot.



Video adapter

Video adapters provide video capability.

Other Adapter Cards

The following are some other adapter cards.

- **Wireless NIC** - A wireless NIC connects a computer to a network using radio frequencies.
- **Capture card** - Capture cards send a video signal to a computer so that the signal can be recorded to a storage drive with video capture software.
- **TV tuner card** - These provide the ability to watch and record television signals on a PC by connecting a cable television, satellite, or antenna to the installed tuner card.
- **Universal Serial Bus (USB) controller card** – Provides additional USB ports to connect the computer to peripheral devices.

It should be noted that some of these adapter cards can be integrated on the motherboard.
Note: Older computers may also have a modem adapter, Accelerated Graphics Port (AGP), a Small Computer System Interface (SCSI) adapter, and more.

Expansion Slots

Slide show. Select the next button to progress.
Computers have expansion slots on the motherboard to install adapter cards. The type of adapter card connector must match the expansion slot.

PCI

Peripheral Component Interconnect is a 32-bit or 64-bit expansion slot. It is currently found in few computers. PCI expansion slots have become mostly obsolete.

Mini-PCI

This is smaller version of PCI found in some laptops. Mini PCI has three different form factors; Type I, Type II, and Type III.

PCI-X

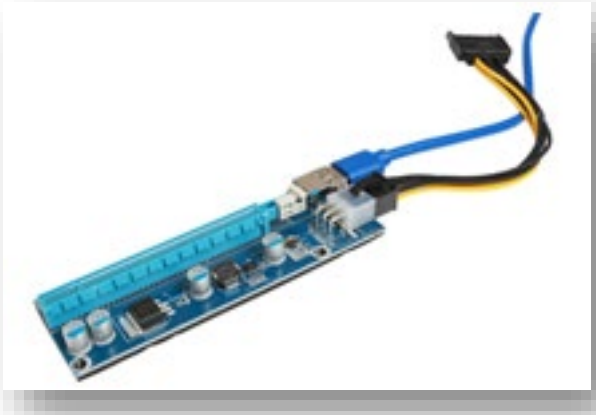
PCI eXtended is an updated version of the standard PCI. It uses a 32-bit bus with higher bandwidth than the PCI bus. PCI-X can operate up to four times faster than PCI. PCI-X expansion slots have become mostly obsolete.

PCIe

PCI Express is a 64-bit parallel interface that is backward compatible with 32-bit PCI devices. PCIe is a serial point-to-point connection with a different physical interface that was designed to supersede both PCI and PCI-X. There are four sizes (lengths): PCI Express x1, PCI Express x4, PCI Express x8, and PCI Express x16.'PCIe x4' connections have four data lanes. 'PCIe x8' connections have eight data lanes. 'PCIe x16' connections have sixteen data lanes.

Riser Card

A riser card can be added to a computer to provide additional expansion slots for more expansion cards.



AGP

Accelerated Graphics Port (AGP) was a high speed slot for attaching an AGP video card. The AGP has been superceeded by PCI. Few motherboards still use this technology today

PCIe Versions

Version	GB/s for x1	GB/s for x8
2	.5	8
3	.985	8
4	1.969	31.508
5	3.938	63.015

Note: GB/s is gigabytes per second.

Every version of PCIe is backward-compatible with all other versions, for example, if you have a motherboard that supports version 4, you can still use version 3 PCIe components. The speed of the bus will be determined by the lowest version component installed.
PCIe can supply up to 25 watts of power to each slot. For a graphics card, it can supply up to 75 watts. For very powerful graphics cards, an additional 75 watts can be supplied by a PCIe power connector from the power supply.

1.2.6 Hard Disk Drives and SSDs

1.2.6.1 Types of Storage Devices

A number of different types of devices are available for data storage on a PC, as shown in the figure. Data drives provide non-volatile storage of data, meaning that when the drive loses power, the data is retained and available the next time the drive is powered on. Some drives have fixed media, and other drives have removable media. Some offer the ability to read and write data, while others only allow data to be accessed, but not written. Data storage devices can be classified according to the media on which the data is stored; magnetic like HDD and tape drives, solid state, or optical.

Hard Disk Drive

Solid State Drive

Optical Drive

Tape Drive

1.2.6.2 Storage Device Interfaces

Internal storage devices often connect to the motherboard using Serial AT Attachment (SATA) connections. The SATA standards define the way that data is transferred, the transfer rates, and physical characteristics of the cables and connectors.

There are three main versions of the SATA standard: SATA 1, SATA 2, and SATA 3, as shown in the figure. The cables and connectors are the same, but the data transfer speeds are different. SATA 1 allows for a maximum data transfer rate of 1.5 Gb/s while SATA 2 can reach up to 3 Gb/s. SATA 3 is the fastest with speeds up to 6 Gb/s.

Note: Legacy internal drive connection methods include the Parallel ATA standards known as Integrated Drive Electronics (IDE) and Enhanced Integrated Drive Electronics (EIDE).

Small Computer System Interface (SCSI) is another interface between motherboards and data storage devices. It is an older standard that originally used parallel, rather than serial, data transfers. A new version of SCSI known as Serially Attached SCSI (SAS) has been developed. SAS is a popular interface used for server storage.

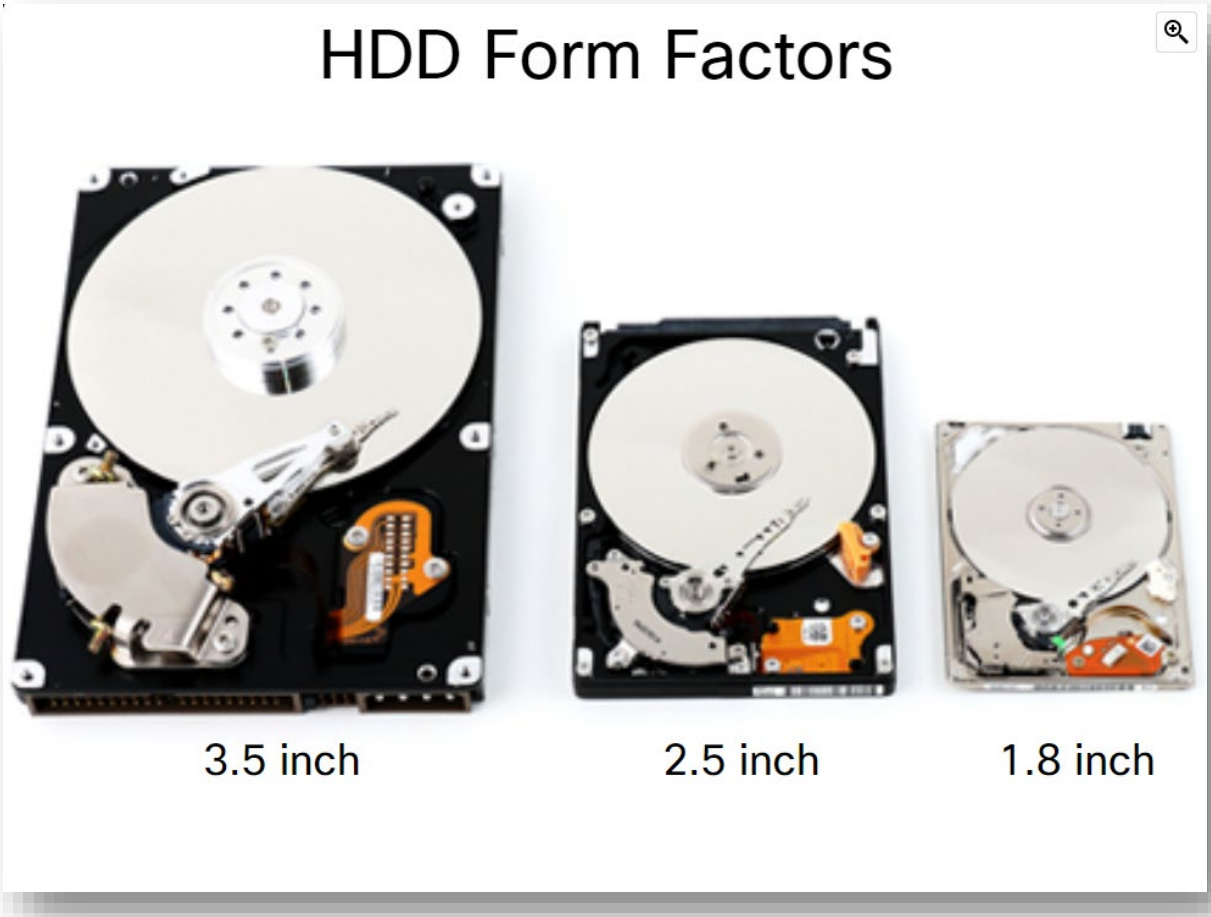
Storage Device Interfaces

ATA	Parallel (PATA)	IDE	8.3 Mb/s
		EIDE	16.6 Mb/s
	Serial (SATA)	SATA 1	1.5 Gb/s
		SATA 2	3.0 Gb/s
		SATA 3	6.0 Gb/s

1.2.6.3 Magnetic Media Storage

Hard Disk Drive (HDD)

HDDs are the traditional magnetic disk devices that have been used for years. Their storage capacity ranges from gigabytes (GBs) to terabytes (TBs). Their speed is measured in revolutions per minute (RPM). This indicates how fast the spindle turns the platters that hold the data. The faster the spindle speed, the faster a hard drive can find data on the platters. This can correspond to faster transfer speeds. Common hard drive spindle speeds include 5400, 7200, 10,000, and 15,000 RPM. HDDs come in 1.8, 2.5 and 3.5 inch form factors, as shown in Figure 1. The 3.5 inch form factor is standard for personal computers. 2.5 inch HDDs are typically used in mobile devices. 1.8 inch HDDs were used in portable media players and other mobile applications, but are seldom used in new devices.



Tape Drive

Magnetic tapes are most often used for archiving data. At one time they were useful for backing up PCs, however as HDDs became cheaper, external HDD drives are now frequently used for this purpose. However, tape backups are still used in enterprise networks. Tape drives use a magnetic read/write head and removable tape cartridge, as shown in Figure 2. Although data retrieval using a tape drive can be fast, locating specific data is slow because the tape must be wound on a reel until the data is found. Common tape storage capacities vary between a few GBs to many TBs.

1.2.6.4 Semiconductor Storage

Solid-state drives (SSD) store data as electrical charges in semiconductor flash memory. This makes SSDs much faster than magnetic HDDs. SSD storage capacity ranges from around 120 GBs to many TBs. SSDs have no moving parts, make no noise, are more energy efficient, and produce less heat than HDDs. Because SSDs have no moving parts to fail, they are considered to be more reliable than HDDs.

SSDs come in three form factors:

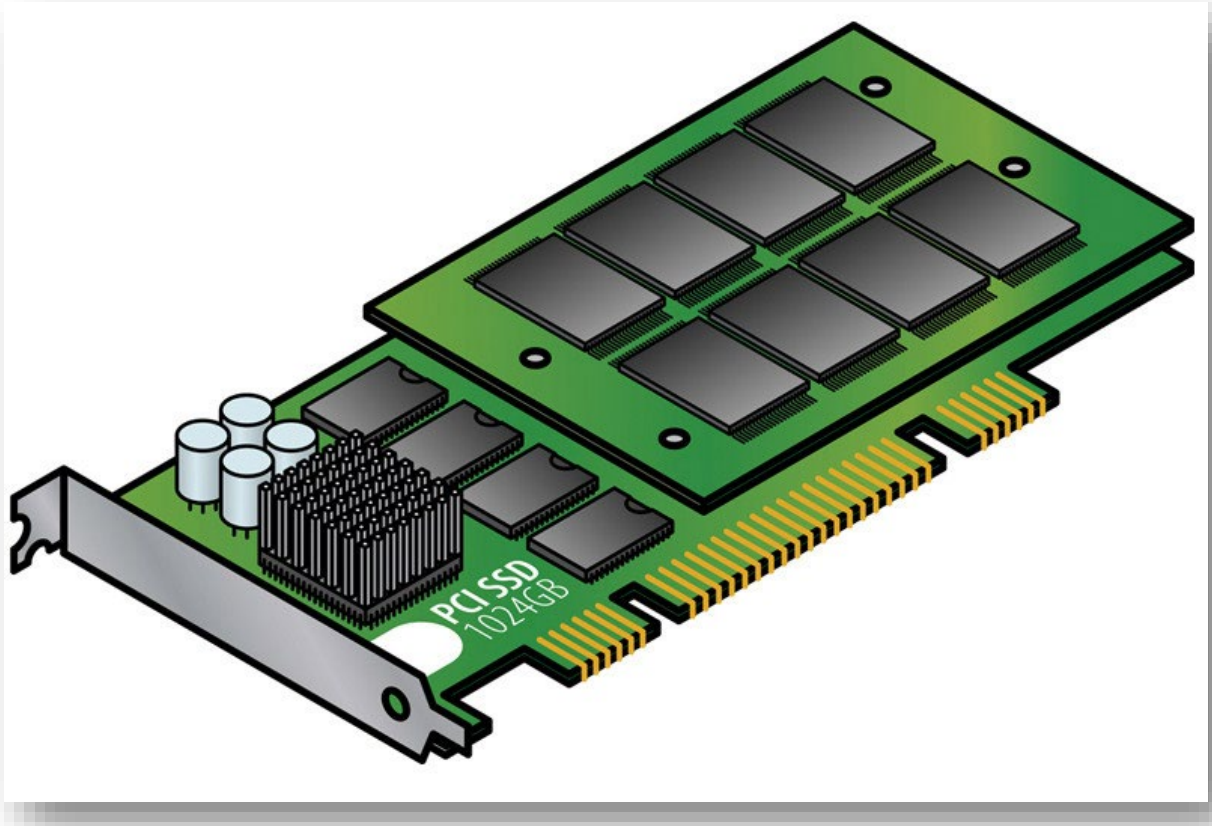
- **Disc drive form factor** – These are similar to an HDD in which the semiconductor memory is in a closed package that can be mounted in computer cases like an HDD. They can be 2.5, 3.5, and 1.8 inches, although those are rare.
- **Expansion cards** – This plugs directly into the motherboard and mounts in the computer case like other expansion cards.

- **mSata or M.2 modules** – These packages may use a special socket. M.2 is a standard for computer expansion cards. It is a family of standards that specify physical aspects of expansion cards such as connectors and dimension.

SSD 2.5" Drive

SSD M.2 Drive

SSD Adapter Card



The following figure shows the 2.5 inch and M.2 form factors in comparison to a 3.5 inch magnetic HDD.

The Non-Volatile Memory Express (NVMe) specification was developed specifically to allow computers to take greater advantage of the features of SSDs by providing a standard interface between SSDs, the PCIe bus, and operating systems. NVMe allows compliant SSD drives to attach to the PCIe bus without requiring special drivers, in much the same way that USB flash drives can be used in multiple computers without requiring installation on each.

Finally, Solid State Hybrid Drives (SSHDs) are a compromise between a magnetic HDD and an SSD. They are faster than an HDD but less expensive than an SSD. They combine a magnetic HDD with onboard flash memory serving as a non-volatile cache. The SSHD drive automatically caches data that is frequently accessed, which can speed up certain operations such as operating system start up.

1.2.7 Optical Storage Devices

1.2.7.1 Types of Optical Storage Devices

Optical drives are a type of removable media storage device that use lasers to read and write data on optical media. They were developed to overcome the storage capacity limitations of removable magnetic media such as floppy discs and magnetic storage cartridges. The figure shows an internal optical drive

Types of Optical Media

There are three types of optical drives:

- **Compact Disc (CD)** - audio and data
- **Digital Versatile Disc (DVD)** - digital video and data
- **Blu-ray Disc (BD)** - HD digital video and data

CD, DVD, and BD media can be pre-recorded (read only), recordable (write once), or re-recordable (read and write multiple times). DVD and BD media can also be single layer (SL) or dual layer (DL). Dual layer media roughly doubles the capacity of a single disc.

The table describes the various types of optical media and their approximate storage capacities.

Optical Media	Description	Storage Capacity
CD-ROM	CD read-only memory media that is pre-recorded	700 MB
CD-R	CD recordable media that can be recorded one time	
CD-RW	CD rewritable media that can be recorded, erased, and re-recorded	
DVD-ROM	DVD read-only memory media that is pre-recorded	

DVD-RAM	DVD rewritable media that can be recorded, erased, and re-recorded	4.7 GB (Single-Layer) 8.5 GB (Dual-Layer)
DVD+/-R	DVD recordable media that can be recorded one time	
DVD+/-RW	DVD rewritable media that can be recorded, erased, and re-recorded	
BD-ROM	Blu-ray read-only media that is pre-recorded with movies, games, or software	25 GB (Single-Layer) 50 GB (Dual-Layer)
BD-R	Blu-ray recordable media that can be recorded one time	
BD-RE	Blu-ray rewritable media that can be recorded, erased, and re-recorded	

1.2.8 Ports, Cables, and Adaptors

1.2.8.1 Video Ports and Cables

Video Ports and Cables

A video port connects a monitor cable to a computer. Video ports and monitor cables transfer analog signals, digital signals, or both. Computers are digital devices that create digital signals. The digital signals are sent to the graphics card where they are transmitted through a cable to a display.

DVI (Digital Visual Interface)

The DVI connector is usually white and consists of as many as 24 pins (three rows of eight pins) for digital signals, up to 4 pins for analog signals, and a flat pin called a ground bar.

DisplayPort

DisplayPort is an interface technology that is designed to connect high-end graphics-capable PCs and displays, as well as home theater equipment and displays.

High-Definition Multimedia Interface (HDMI)

HDMI was developed specifically for high-definition televisions. However, its digital features also make it a good candidate for computers.

Thunderbolt 1 or 2

Thunderbolt allows for high-speed connection of peripherals such as hard drives, RAID arrays, network interfaces, and it can transmit high-definition video using the DisplayPort protocol.

Thunderbolt 3

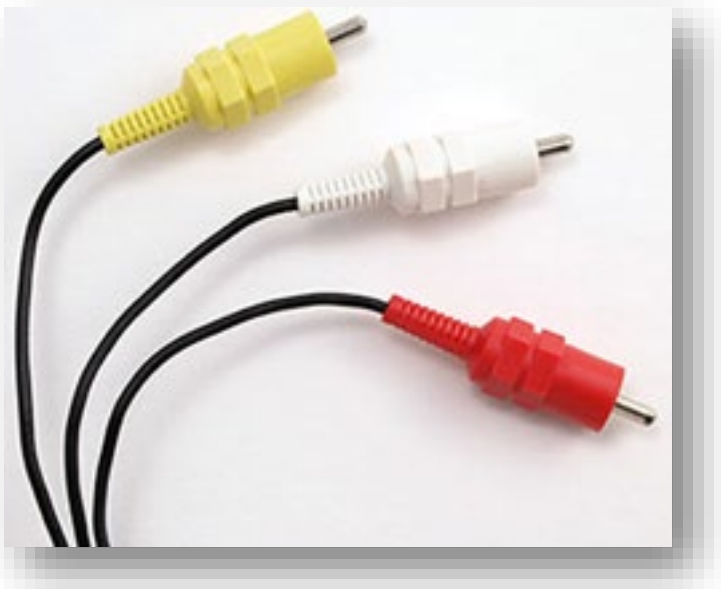
Thunderbolt 3 uses the same connector as USB-C. It has twice the bandwidth of Thunderbolt 2, uses less power, and can provide two 4K monitors with video.

Video Graphics Array (VGA)

This is a connector for analog video. It has 3 rows and 15 pins. It is also sometimes referred to as the DE-15 or HD-15 connector.

Radio Corporation of America (RCA)

RCA connectors have a central plug with a ring around it and are used to carry audio or video. RCA connectors are often found in groups of three, where a yellow connector carries video and a pair of red and white connectors carries left and right audio channels.



More About DVI

There are 5 types of DVI that are available for digital and analog output and also for single link and dual link which offers extra bandwidth. DVI-D only supports digital devices and outputs. DVI-A will only support analog output. DVI-I supports digital outputs and analog devices.
There are currently two main types of DVI connectors, DVI-I and DVI-D .DVI-D provides a digital only signal, while DVI-I can support digital and analog signals. DVI is disappearing as quickly as it appeared. It's still seen in some monitors alongside VGA, which is finally starting to fade in favor of HDMI.

1.2.8.2 Other Ports and Cables

Other Ports and Cables

Input/output (I/O) ports on a computer connect peripheral devices such as printers, scanners, and portable drives. In addition to the ports and interfaces previously discussed, a computer may also have other ports.

Personal System 2 (PS/2)

A PS/2 port connects a keyboard or a mouse to a computer. The PS/2 port is a 6-pin mini-DIN female connector. The connectors for the keyboard and mouse are often colored differently. If the ports are not color-coded, look for a small figure of a mouse or keyboard next to each port.

Audio and Game Port

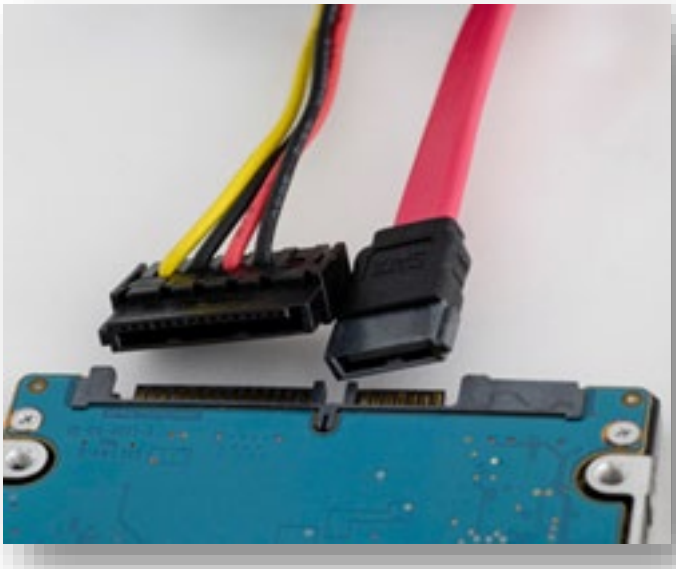
Audio ports connect audio devices to the computer. Analog ports typically include a line in port to connect to an external source (e.g., stereo system), a microphone port, and line out ports to connect speakers or headphones. The game port connects to a joystick or MIDI-interfaced device.

Network

A network port, also known as an RJ-45 or 8P8C port has 8 pins and connects devices to a network. The connection speed depends on the type of network port. The maximum length of the Ethernet network cable is 100 m (328 ft.).

Serial AT Attachment (SATA)

The SATA cable connects SATA devices to the SATA interface using a 7-pin data cable. SATA connectors have an L-shaped slot so the cable only fits in one orientation. This cable does not supply any power to the SATA device. A separate power cable provides power to the drive.



Integrated Drive Electronics (IDE)

The IDE cable is a ribbon cable used to connect storage drives inside the computer. The two most common types of IDE ribbon cables are the 34-pin cable used for floppy drives and the 40-pin cable for hard drives and optical drives.

The Universal Serial Bus (USB)

USB is a standard interface that connects peripheral devices to a computer. USB devices are hot-swappable, which means that users can connect and disconnect the devices while the computer is powered on.

1.2.8.3 Adapters and Converters

Adapters and Converters

There are many connection standards in use today. Many are interoperable but require specialized components. These components are called adapters and converters:

- **Adapter** – This is a component that physically connects one technology to another. For example, a DVI to HDMI adapter. The adapter could be one component or a cable with different ends.

- **Converter** – This performs the same function as an adapter but also translates the signals from one technology to the other. For example, a USB 3.0 to SATA converter enables a hard disk drive to be used as a flash drive.

DVI to VGA adapter

This adapter is used to connect a VGA cable to a DVI port.

USB to Ethernet converter

This converter is used to convert USB to an Ethernet.

USB to PS/2 adapter

This adapter is used to connect a USB keyboard or mouse to a PS/2 port.

DVI to HDMI adapter

This adapter is used to connect an HDMI cable to a DVI port.

Molex to SATA adapter

This is used to connect a SATA drive to a Molex power cable.

HDMI to VGA converter

This converter is used to convert VGA signals to HDMI signals.

1.2.9 Input Devices

1.2.9.1 The Original Input Devices

The Original Input Devices

Input devices allow the user to communicate with a computer. The images below are some of the first input devices.

Keyboard and Mouse

These are the two most commonly used input devices. Keyboards are typically used for creating text documents and emails. The mouse is used to navigate the graphical user interface (GUI). Laptops also have touchpads to provide built-in keyboard and mouse features. The keyboard was the very first type of input device.

ADF / Flatbed Scanner

These devices digitize an image or document. A photograph or document is placed on the flat glass surface and the scan head then moves under the glass. The digitization of the image is stored as a file that can be displayed, printed, emailed, or altered. Some of these scanners have automatic document feeders (ADF) to support multiple page input.

Joystick and Gamepad

These are input devices for playing games. Gamepads allow the player to control movement and views with small sticks and multiple buttons. Many gamepads also have triggers that register the amount of pressure the player puts on them. Joysticks are often used to play flight simulation-style games.

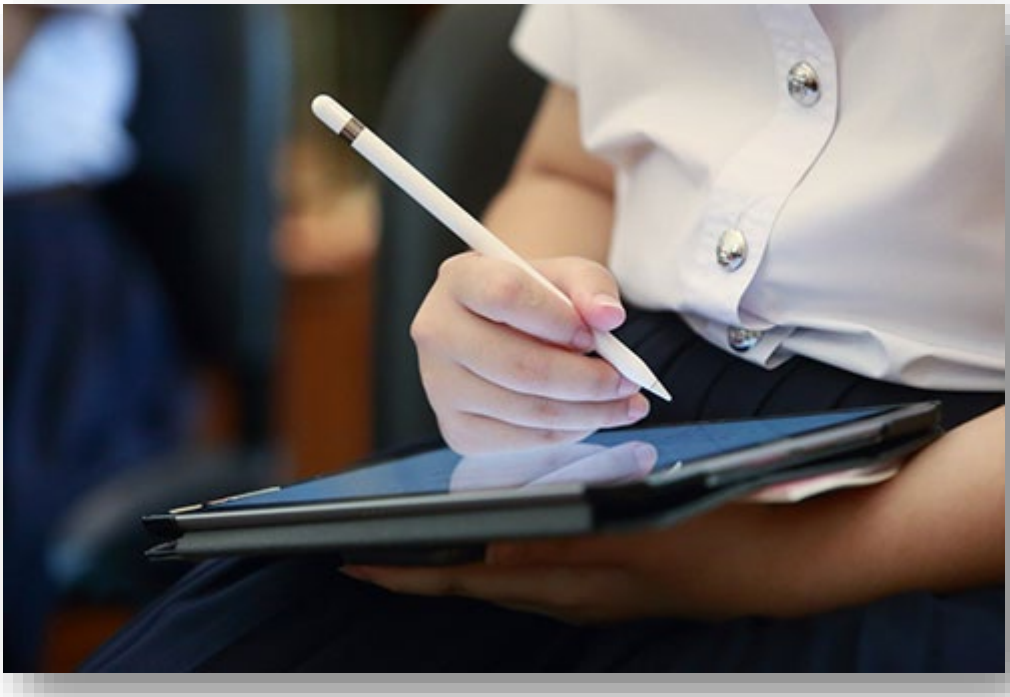
KVM Switch

A keyboard, video, and mouse (KVM) switch is a hardware device that can be used to control more than one computer while using a single keyboard, monitor, and mouse. For businesses, KVM switches provide cost-efficient access to multiple servers. Home users can save space using a KVM switch to connect multiple computers to one keyboard, monitor, and mouse. Some KVM switches have the capability to share USB devices and speakers with multiple computers.

1.2.9.2 New Input Devices

New Input Devices

Some new input devices include touch screen, a stylus, a magnetic strip reader and a barcode scanner.



Touch screen

These input devices have touch or pressure sensitive screens. The computer receives instructions specific to the place on the screen that the user touches.

Stylus

This device is a type of digitizer that allows a designer or artist to create blueprints, images, or other artwork by using a pen-like tool called a stylus on a surface that senses where the tip is touching it. Some digitizers have more than one surface, or sensor, and allow the user to create 3D models by performing actions with the stylus in mid-air.

Magnetic Stripe Reader

Also called a magstripe reader, this device reads information magnetically encoded on the back of plastic cards, such as identification badges or credit cards.
Also shown at the top of the device is a chip reader. For cards with chips, the card is inserted into the device and the device reads the chip. Chip reading provides much more security of the user's data because each transaction is a unique code that cannot be used again.

Barcode Scanner

This type of scanner, also called a price scanner, reads the information contained in the barcodes affixed to most products. They can be hand-held, wireless devices, or a stationary device. The light source on the reader captures the barcode image and translates the image into computer readable content. This device is typically used at checkout counters in stores or for determining inventory levels.

1.2.9.3 More New Input Devices

More New Input Devices

Digital Camera

These input devices capture images and videos that can be stored, displayed, printed, or altered.

Webcam

These devices are video cameras that can be integrated into a computer or they can be external. They are typically used for video conferencing or to stream live video onto the internet.

Signature Pad

This is a device that electronically captures a person's signature. A person uses a stylus to sign on the screen. Since the electronic signature is legal, it is typically used to establish receipt of deliveries or to sign agreements or contracts.

Smart Card Reader

These input devices are typically used on a computer to authenticate the user. A smart card may be the size of a credit card with an embedded integrated circuit that is typically under a gold contact pad on one side of the card.

Microphone

This device is a type of digitizer that allows a user to speak into a computer and have their voice digitized. Voice, music, or sounds can be stored on the computer to be played back, uploaded, or emailed. This device can also be used as input for games and communication software.

1.2.9.4 Most Recent Input Devices

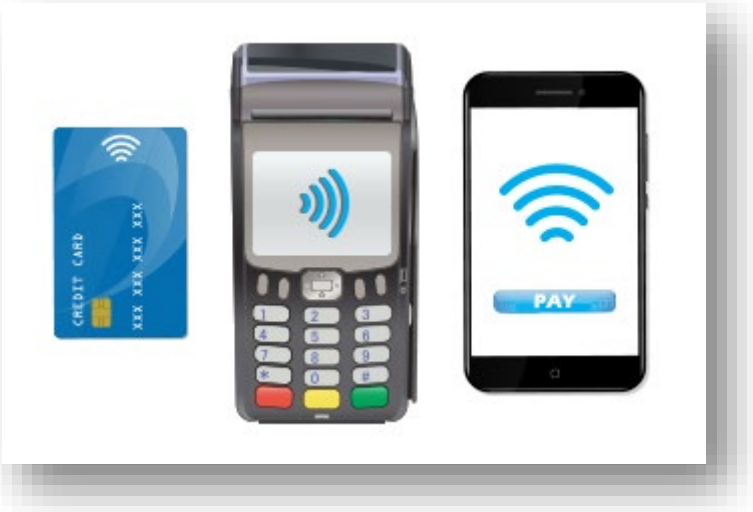
Most Recent Input Devices

The newest input devices include NFC devices and terminals, facial recognition scanners, fingerprint scanners, voice recognition scanners, and virtual reality headsets.

NFC Devices and Terminals

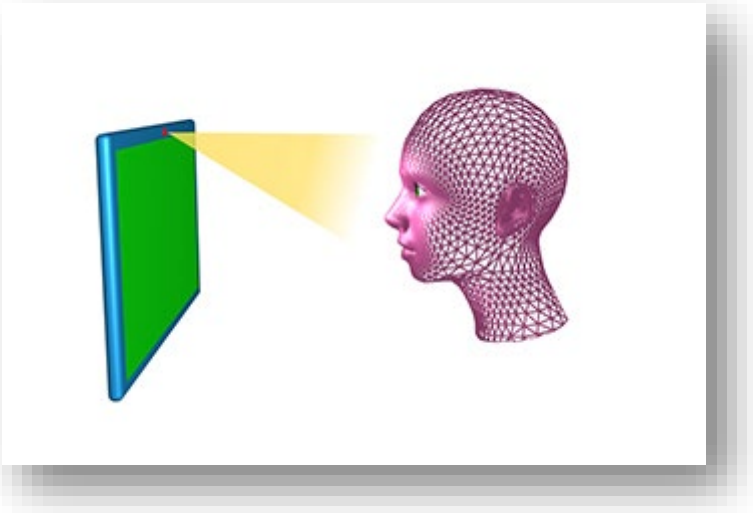
Near Field Communication tap to pay devices, such as credit cards or smart phones, are able to read and write to an NFC chip. This allows the NFC-powered terminal to subtract money

from the balance on the card. Two NFC capable devices can also transfer data such as photographs, links, or contacts between them.



Facial Recognition Scanners

These biometric input devices identify a user based on their unique facial features. Many laptops and most smartphones have facial recognition scanners to automate logging in to the device. These devices are typically used to provide secure access to devices or locations.

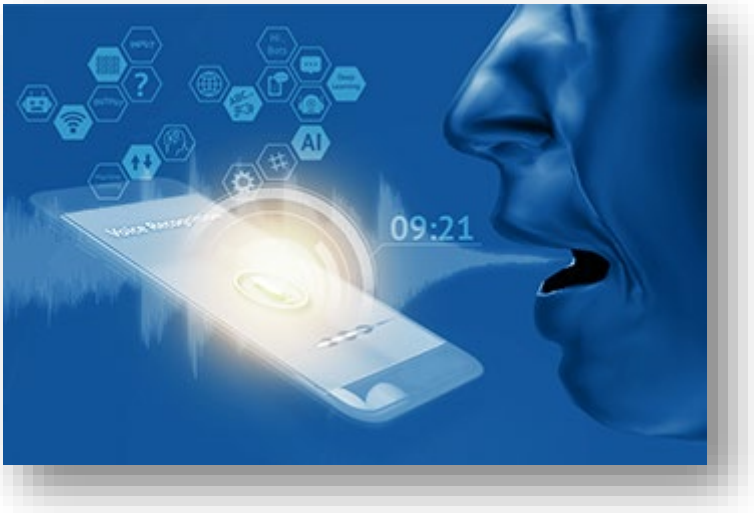


Fingerprint Scanners

These biometric input devices identify a user based on a unique physical feature such as their fingerprints. Many laptops and smart devices have fingerprint readers to automate logging in to the device. These devices are typically used to provide secure access to devices or locations.

Voice Recognition Scanners

These biometric input devices identify a user based on their unique voice. These devices are often used to provide secure access to locations. Voice recognition is also being used as input into personal assistant applications such as Apple's Siri and Amazon's Alexa.



Virtual Reality Headset

These devices are typically used with computer games, simulators, and training applications. They are head-mounted devices that provide separate images for each eye. Most headsets include head-motion and eye-motion tracking sensors. These devices are also output devices delivering video and audio to the wearer.

1.2.10 Output Devices

1.2.10.1 What are Output Devices?

An output device takes binary information (ones and zeroes) from the computer and converts it into a form that is easily understood by the user.
Monitors and projectors are output devices that create visual and audio signals for the user. Virtual Reality (VR) headsets are another type of output device. Televisions may also be output devices. Printers are visual output devices that create hard copies of computer files.

Monitor

Projector

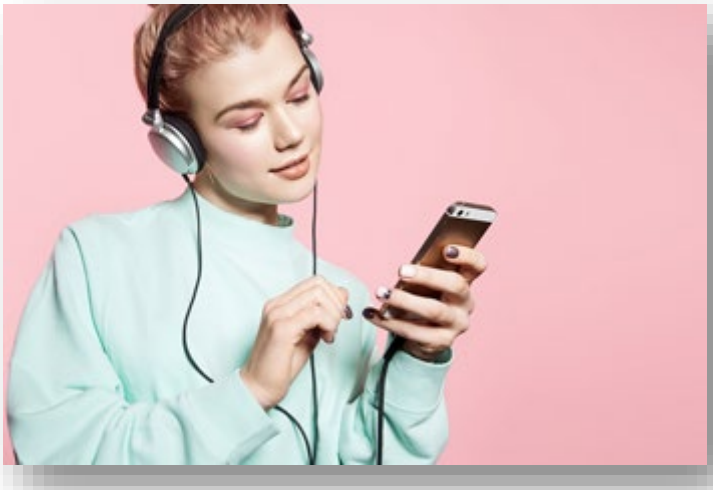
VR Headset

Printer

Speakers and headphones are output devices that produce only audio signals. Output devices make it possible for users to interact with computers

Speakers

Headphones



1.2.10.2 Monitors and Projectors

Monitor

Most monitors use one of three types of technology: LCD, LED, or OLED.
Liquid crystal display (LCD) has two polarizing filters with a liquid crystal solution between them. An electronic current aligns the crystals so that light can pass through or not pass through, creating the image.
Light-emitting diode (LED) is an LCD display that uses LED backlighting. LED has lower power consumption than standard LCD backlighting. The panel is thinner, lighter, brighter, and has better contrast than LCD.
Organic LED (OLED) is a type of LED display that uses a layer of organic material which responds to electrical stimulus to emit light. Each pixel lights individually, resulting in much deeper black levels than LED.

Projector

Most video projectors use LCD or DLP technology. DLP stands for Digital Light Processing. DLP uses a spinning color wheel with an array of mirrors. Each mirror corresponds to a pixel and reflects light toward or away from the projector optics, creating an image of up to 1024 shades of gray. The color wheel then adds the color data to complete the projected image. Different projectors have different numbers of lumens, which affects the level of brightness of the projected image. LCD projectors typically have more lumens (brighter) than DLP projectors. ANSI has a standardized procedure for testing projectors. Projectors tested with this procedure are quoted in "ANSI lumens". Projectors can be easily compared on the basis of their brightness specifications.
Brightness (white light output) measures the total amount of light projected in lumens. The color brightness specification measures red, green, and blue using the same approach used to measure brightness.

1.2.10.3 VR and AR Headsets

Virtual Reality (VR) uses computer technology to create a simulated, three-dimensional environment. The user feels immersed in this ‘virtual world’ and manipulates it. A VR headset completely encases the upper portion of users’ faces, not allowing in any ambient light from their surroundings. Most VR experiences have three-dimensional images that seem life-sized to the user. VR experiences also track a user's motions, and adjust the images on the user's display accordingly.
Augmented Reality (AR) uses similar technology but superimposes images and audio over the real world in real time. AR can provide users with immediate access to information about their real surroundings. An AR headset usually does not close off ambient light to users, allowing them to see their real life surroundings. Not all AR requires a headset. Some AR can simply be downloaded onto a smart phone. Pokemon GO is an early version of an AR game that uses a player’s smart phone to ‘see and capture’ virtual objects in the real world. Other AR devices are smart glasses. They weigh much less than the headsets and are often designed for a specific audience, such as cyclists.

VR Headset

VR headsets can have specific hardware and software platforms. They may be tethered to a controller, standalone, or mobile. They may have a variety of sensors including motion, external visual positioning, camera(s), motion tracking, accelerometer, gyroscope and magnetometer. Resolution and refresh rates vary.

AR Headset

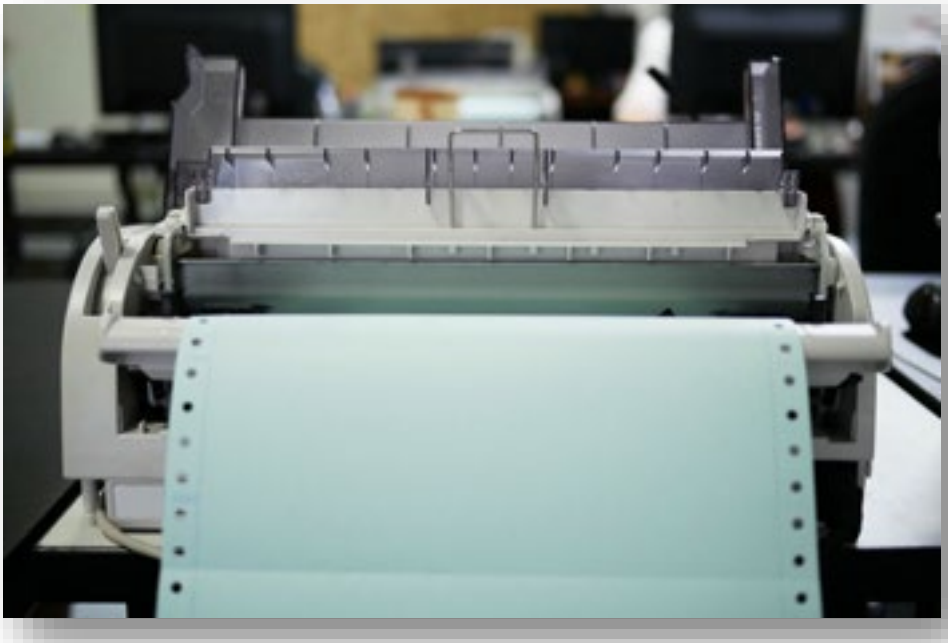
AR headsets and smart glasses come with a wide array of features. Most have a camera, motion sensors, GPS, a CPU, battery power, and a controller. Many also have storage, Bluetooth, speakers, and voice control. The Microsoft Hololens is a headset with an integrated holographic processing unit.

1.2.10.4 Printers

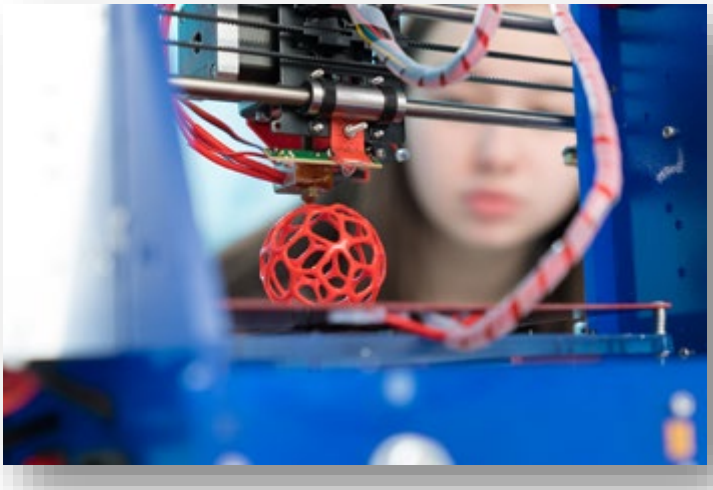
Printers are output devices that create hard copies of files. A hard copy might be a on a sheet of paper. It could also be a plastic form created from a 3D printer.
Today's printers may be wired, wireless, or both. They use different technology to create the image you see. All printers require printing material (such as ink, toner, liquid plastic, etc.) and a method to place it accurately on the paper or extrude it into the desired shape. All printers have hardware that must be maintained. Most printers also have software, in the form of drivers that must be kept up to date.

Inkjet Printer

Impact Printer



3D Printer



Thermal Printer

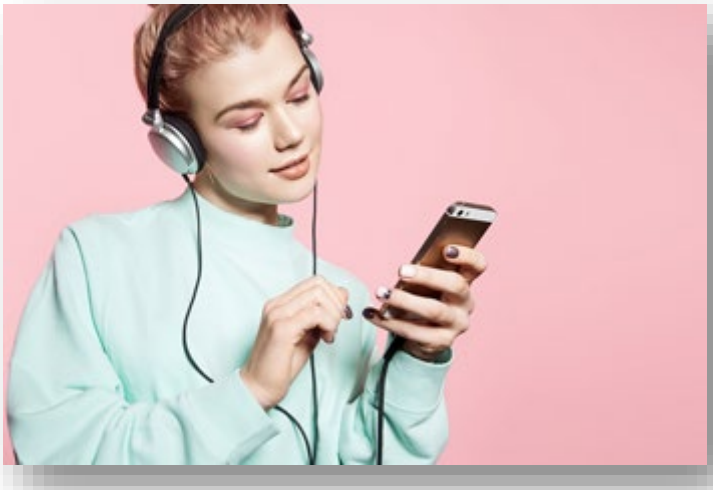
1.2.10.5 Speakers and Headphones

Speakers

Speakers are a type of auditory output device. Most computers and mobile devices have audio support either integrated into the motherboard or on an adapter card. Audio support includes ports that allow input and output of audio signals. The audio card has an amplifier to power headphones and external speakers.

Headphones

Headphones, earbuds, and the earphones found in headsets are all auditory output devices. These may be wired or wireless. Some are Wi-Fi or Bluetooth-enabled.



1.3.1 The Technician’s Toolkit

1.3.1.1 Video Explanation - Technician's Toolkit

Hello everyone. Imagine building a computer with your bare hands. Good thing we don't have to do that. We are here to look at the tools, used to work both outside and inside our computer cases.

We're going to start here with ESD safety. I have an anti-static wrist strap here. And also, I have an anti-static mat. With the anti-static wrist wrap, we put it around our wrist, or our ankle, so it contacts our skin. You can even tighten it. Now, there's an alligator clip that can attach to ground. Ground for us, can be a computer case, or ground on an outlet. The anti-static wrist strap alligator clip can also connect directly to our anti-static mat. And this will ground ourselves correctly with our workspace.

Now, as we continue, sometimes you may find a computer that has not been touched or cleaned, in what seems like a decade. For situations like this, we can use a cleaning tool such as a compressed air can. When you get into a computer, and you find out that a lot of computers can be completely disgusting inside, canned air like this, can help us clean out the CPU heat sync, the CPU fan, the GPU heat sync and fan, and doing so, allows us to keep our devices running cool and without errors. So many problems with computers is because of heat issues. And a can of compressed air should always be in your tool kit.

Let's continue with screwdrivers and magnetic tips. Commonly, the magnet will be weak enough to not affect the sensitive devices within your computer. But they are usually strong enough to assist in not losing, and/or retrieving, screws. If you've ever dropped a screw into your computer case, you'll understand this frustrating game of retrieval. Now, some kits may come with a device like this. An extraction tool. Besides retrieving lost screws, we should talk about the most common type of screws in use.

The most common type of screws are Phillips screws. The Phillips head screwdriver is what we should have in our toolkit for most of our work. Now, some computers might use Torx or flat-head screws. So, we should have those screwdrivers in our kit as well.

While working at a computer, we'll eventually have to verify network connectivity. We should have some basic network connectivity and verification tools in our kit to verify cabling, cable rating, and functionality. This cable tester can save you from experiencing a variety of headaches. If a cable is bad, we should have tools like these crimpers over here that allow us to both cut and terminate cable.

An organized storage case works wonders while working both inside and outside a computer case. This holds true when you're removing screws for a variety of different adapter cards, drives, motherboard stand offs, and more. Keeping things organized using cases, allows us to save a lot of headaches from occurring. Keeping organized is the top tool of the IT professional.

Get comfortable using the tools in your toolkit. Build out your own toolkit now. But keep in mind, your kit will continue to grow, and become customized based on your evolving skills, as you become an IT professional.

1.3.2 Computer Disassembly

1.3.2.1 Lab - Safety

In this lab, you will use common safety procedures while building and/or servicing computer hardware.

- Part 1: Personal Safety
- Part 2: Electrical Safety
- Part 3: Fire Safety
- Part 4: Compliance with Government Regulations

Background / Scenarios

Safe working conditions help prevent injury to people and damage to computer equipment. A safe workspace is clean, organized, and properly lit. Everyone must understand and follow safety procedures.

In this activity, you will review some of the safety procedures.

Suggested Resources

 Internet access
 Fire extinguisher
 Safety goggles
 Air filtration mask

Instructions

Part 1: Personal Safety

Some personal safety guidelines can prevent cuts, burns, electrical shock, and damage to eyesight. As a best practice, make sure that a fire extinguisher and first-aid kit are available. Proper cable management can prevent tripping hazards in a network installation.

Here are a few examples of basic safety precautions:

- Remove your watch and jewelry and secure loose clothing.

- Keep food and drinks out of your workspace.
- Wear safety goggles to prevent damage to eyesight.
- Wear an air filtration mask when there is dust or other air contaminants.
- Bend your knees when lifting heavy objects to avoid injuring your back.
- Before cleaning or repairing equipment, make sure that your tools are in good condition. Clean, repair, or replace items that are not functioning adequately.

Question:

What other simple precautions can you take to prevent injury or cause equipment damage while working with computer hardware?

Part 2: Electrical Safety

Following electrical safety guidelines helps to prevent electrical fires, injuries, and fatalities. For example, some printer parts become hot during use. Power supplies contain high voltage.

Questions:

What can you do to prevent injury or damage to printer parts?

Type your answers here.

What can you do to prevent injury or damage power supplies for computers?

Type your answers here.

Equipment Grounding

To protect the technicians, electrical equipment should be grounded to prevent electrocution. If the metal parts in the equipment becomes energized, the equipment ground provides a lower resistant path for the current to flow to the ground rather than through the handler of the faulty device.

Questions

Perform an internet search to answer the following questions:

How do you ground devices, such as PCs and printers?

Type your answers here.

How are large metal equipment racks grounded?

Type your answers here.

Note: In some countries, portable appliance testing is done to ensure that an equipment is safe to use.

Part 3: Fire Safety

Fire can spread rapidly and be very costly. Proper use of a fire extinguisher can prevent a small fire from getting out of control. Locate and read the instructions on the fire extinguishers in your workplace before you need to use them.

When working with computer components, be alert for odors emitting from computers and electronic devices. When electronic components overheat or short out, they emit a burning smell. If there is a fire, follow these safety procedures:

- Never fight a fire that is out of control or not contained.
- Always have a planned fire escape route before beginning any work.
- Get out of the building quickly.
- Contact emergency services for help.

Use a web browser or a fire extinguisher to review the proper procedure to use a fire extinguisher to answer the following questions.

a) How does the memory aid P-A-S-S help with remembering the basic rules of fire extinguisher operation?

b) Each type of fire extinguisher has specific chemicals to fight different types of fires. List the different types of fire extinguishers used in your country or region.

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Part 4: Compliance with Government Regulations

When maintaining a PC or installing new equipment, you should be aware of your compliance to local government regulation with regards to health and safety laws, building codes and environmental regulations.

Health and Safety Laws

For example, Occupational Safety and Health Administration (OSHA) standards are a set of guidelines and requirements to minimize health and safety risks in United States-based workplaces. The employers provide safe and healthy working environments for their employees. The employees should be informed and complied with the guidelines, report any hazards and modify or install any equipment or materials without proper authorization.

Questions:
Perform an internet search to locate the governing body for health and safety in the workplace for your country. Record the official title and link to the website.

Using the answer to previous question, document the safety guidance or standards about electrical safety from the website. Be sure to include anything that could prevent electrical hazards.

Building Codes

Building codes are the legal regulations that must be followed to meet the minimum acceptable level of safety for building and structures. The building regulations ensure the heath, safety, and protection of the public during construction and occupancy of the buildings.
The building regulations are determined by the appropriate authorities and can vary depending on the location.

Question:
Perform an internet search for your local building codes. List of some of the building codes that is adopted locally.

Environmental Regulations

When any equipment has reached the end of life, it should be disposed correctly. The equipment may be donated, recycled, or destroyed per environmental regulations.

Question:
A business has replaced 50 laptops and looking for a way to disposed of them properly. Find a local facility that can disposed of them properly and describe what will the local facility do with the laptops.

Reflection Questions

In your opinion, what is the most important safety rule when servicing a computer? Explain.

1.3.2.2 Video Demonstration – Computer Disassembly

Hello everyone, can you believe it? We're here to disassemble a perfectly good and working computer. But that's how we learn and that's how we're going to practice becoming the best IT professional.

Let's get started on disassembling. To begin, I'm going to power off the computer, then I'm going to disconnect the power cable from the power supply. Commonly, we like to depress the power button and hold it down a little bit longer, let it get rid of any excess power on the system.

On the back of the computer, now we can remove all these video and audio cables, mice and keyboard. Also, I'm pulling my network cable as well. Network cable, mouse, keyboard, I can remove the audio cable and then even my video connector. The computer is completely unplugged and now I'm going to lay it on its side and we're going to get to the internals. I'm going to move the mouse and keyboard to make it easy. I'm going to get the computer on its side. I can remove this screw on the back. You can either do this by hand or use a screwdriver if you need, then we can slide the case cover.

We'll start again on the inside. With my case opened up, laying on its side, you need to start with our hard drive. My solid state hard drive is mounted right here. We're going to zoom in on that and we're going to disassemble.

First what we're going to is take off the SATA power connector which is right here. You can safely pull that straight back and disconnect. Then we have the SATA data connector, which I can also pull and disconnect.

At this time, I can now unscrew that hard drive and we can pull it right out of there. I'll take that corresponding screw driver with the correct bit and we'll remove these screws that are holding it on. With the first screw removed, hold it up so it doesn't drop, and take out the next screw that's holding it in. Commonly, your hard drives will have four screws to remove, but for the sake of recording I've got two. Hard drive is out and the screw is removed. At this point, we're going to continue on. I'm going to do the optical disk drive.

The optical disk drive is up here at the top of my case, so we'll zoom in on that next and we'll remove it. Let's continue on and remove this optical drive. This is the best view you are going to get in this tight space. We got the power supply here, we got the optical drive right next to it. So what we're going to do here is remove the SATA power connector from our optical drive which is this one and grab it with my fingers right there and pop it out. Right behind that, we have the smaller SATA data connector, so I'm going to remove that as well. Just grabbing it and pulling it straight out as well. The power and the data is now disconnected from this SATA optical disk drive. We got a couple things to get it out though.

Number one is I've got two screws, which you'll see one here and one here that we need to remove. So we'll remove those two screws. As we're removing those two screws, I want you to think about something. The power supply is right behind this optical drive and we've got the optical drive that was screwed in. Which way is this optical drive going to go to get out of

our case? Does it go back into the power supply or we have to pull this thing out the front? That's the conversation that you got to have when you work on these cases.

For us, screws are out, optical drive is ready to go nowhere. What we're going to need to do is turn this case so the front is facing up and we need to pop off the front plastic of our case, let's do that next. So that optical drive needs to move, it's not going anywhere, it's not going back and it's not going forward. So what we need to do is pop up the front plastic part of our case. I've got three of these over here, there's three on the other side. I'll show you this, what I'm going to do is pull them up, I'm going to pull them up, I'm going to push that case forward and I can pop off this front cover. And now, the thing just popped off. What I can do is take this optical drive and I'm push it from the back, look at that. It's going to slide right out for me, optical drive out. Let's continue on and go through more components of disassembly.

Let's continue and we're going to remove the power supply. In order to do this, we need to disconnect it from the motherboard. Up here at the top, you can see I have a 24-pin main power supply connection to my motherboard. I've got that little lever right there. We're going to pull that back and pull this thing straight up off the motherboard. I'm going to get my hand in there, put my finger on that little lever and then I'm going to grab it and pull straight up, got it, there you go, with the lever and all, you can see that clip on there. I'm not done yet though, as we take a closer look inside this case, we see that there's this other ATX CPU power connector. You may not have this on the board, it really does depend on your computer. But this one also has a little lever. This lever you can see right down over here. Let's zoom in on that and we'll get this one removed as well. We zoomed in, you can see it better. It's a four pin right there and we see that it's got that little clip on it as well. I'm going to reach my hand in there, try to not to obstruct the cameras as best as possible, which is not easy, because there is a very small space to work in here. I'm going to grab that thing, I'm going to put my thumb on that lever and pull straight up and we got it. It's the four pin ATX CPU power connector. It gives us extra power to the board for our components. So we're good on the power disconnects.

We're going to zoom out a little bit and we're going to take out some adapter cards and finish off our disassembly. We've got one adapter card here and that's our video card and we're going to remove this thing. In order to remove it, what I need to do is take off this. What is this? This is going to be our mounting bracket. When I remove this mounting bracket, it will allow us to actually lift up and pull out this graphics card. I'll take my screwdriver and we're going to grab that screw on that mounting bracket and we're going to unscrew it like so. With that being unscrewed, which now it's out, I can go ahead and I can just lift this off. This secures any cards I have so they're not going to shift or be removed.

At this time, I'm going to reach into that computer case and my graphics card has a little lever on the bottom. This lever's very difficult to see so we're going to do some camera movement here. Here's a better angle, we got a diagonal view of this graphics card. If you look closely down there, I'll try not to block the light as I get in this small space. There's this little black lever right here. If I try to pull up on the card right now, like right here and pull up, it's not going anywhere. So what I have to do is pull this lever out to the left, which is towards my yellow wand there and I can lift straight up on the card and it will come out of the PCI slot that I have. I reach in there, so you can see it, I'll pull that lever right there, pull it towards me, I can lift the card straight up, now it pops out. You can see where the lever is actually holding onto right down there, over here, which comes in handy so your card won't fall of the slot. I'll pull that card out, it's gone.

We'll continue onwards now and we're going to work on that power supply. We may have already removed our power supply connectors off they motherboard, but it's time to remove the power supply from the case. In order to do this, I'm going to tilt my power supply up in the case and we're going to take a look at a couple screws. We've got screws of, screw number one, screw number two, screw number three and screw number four. Now we need to take these out in order to get access to slide this power supply out of the case. I think you can tell which way it's going to slide out. See how the middle of the case is? It's not going towards me, it's going to slide out into the case. So let's go into the case, so let's do this. Take my screwdriver and let's unscrew. This is that moment where you stop and you make sure it's not going to fall literally into the case at a vertical angle. My power supply here actually has a lever. And the lever I'll show you in a little bit is down below and that's keeping the power supply locked in. Even now, it's not shifting where there's one screw left.

Now that's not going to be common for every single computer case, so keep in mind, for you it might be a good time to hold onto the power supply as you take out your last screw. I can do the same, because you've already seen the other ones in video. So last screw is out and take a look my power supply is not moving, it's still locked. And that's because of another angle with the video I'm going to show you. If you look closely, down here at the bottom corner of my power supply, right over here, that's a locking lever. That is preventing my power supply from moving into the case. So what I have to do is take my hand and I'm going to depress with my thumb on that lever, see how it moves. Then you push down and then case is going to be able to allow our parts to come right out and there it goes.

So we're going to remove the rest of the connectors and we've got these front panel connectors inside of here. I've got one for audio on that front panel, I've got one for USB and I've got another one for the front panel power, as well as, it's going to be a power LED reset switch, even a speaker for BIOS. So all we need to do is just take on these and lightly pull them straight up and there goes our audio, there goes our USB, and lastly our front panel connectors for our power button, reset button, speaker and more.

Next, we need to get the memory out, which is going to be our RAM, our random access memory, which are two memory chips here. You see them right here and right here. We're going to zoom in on those, I'm going to take a look at how to remove those from our computer case.

Now that we've located, we zoomed in on our two RAM modules, we're going to release that locking tabs on both of the memory modules on the motherboard and it's on both sides. After that, we can gently lift each of these out of the motherboard slots and we can place them on our antistatic mat for safety. So I'll go ahead and I'll pop the one locking lever, so you can pull it down. Go on the other side, which is a small case and you can lift that RAM module out and put it on our mat. You can do the same thing for the second module, pull it on the locking levers and then lift that card right out, awesome.
At this time, we're finished with our disassembly. There's always more that we could take out, but due to the fragile nature of our remaining items I've got a CPU with a CPU heatsink and fan and I've got the motherboard itself with the case fans. This completes the disassembly of our computer tower.

1.3.2.3 Lab - Disassemble a Computer

Introduction

In this lab, you will disassemble a desktop computer using safe lab procedures and the proper tools. Use extreme care and follow all safety procedures. Familiarize yourself with the tools you will be using in this lab.

The goal of this lab is to separate the components and practice using tools probably. The separated components can be used in a later lab for assembly.

This lab does not include removing the motherboard, CPU, and cooling device from the computer due to the replacement cost of these items. If possible, allow students to remove these components from spare or broken computers that are kept in the classroom for part identification and demonstration.

Part 1: Preparation
Part 2: Parts Removal

Recommended Tools

Safety glasses Antistatic wrist strap Antistatic mat Flat head screwdrivers Phillips head screwdrivers Torx screwdrivers Hex driver	Part retriever Thermal compound Can of compressed air Cable ties Parts organizer Containers for storing computer parts Antistatic bags for electronic parts

Instructions

Part 1: Preparation

Step 1: Power off the Computer and remove peripheral items.

a) Turn off the power to the computer and disconnect the power cable from the wall and the power supply.
b) Remove all external peripheral items, such as Ethernet cables, monitors, keyboards.

Step 2: Open the Computer Case.

Generally, computer cases are held in place using one or a combination of these three ways below:

Screwless
These cases are held together using metal or plastic clips. To open the case, the clips are released by pressing buttons or switches to remove the side panel.

Screw

Locate all the screws that secure the side panels to the back of the computer. These screws are located at the edge of the case. Use the proper size and type of screwdriver to remove the side panel screws. Do not remove the screws that secure the power supply to the case. Put all the screws in one place, such as a compartment in the parts organizer or small cup. Label the compartment or cup with a piece of masking tape on which you have written **side panel screws**. Remove the side panels from the case.

a. Locate the hard drive. Carefully disconnect the power and data cables from the back of the hard drive. b. Locate all the screws that secure the hard drive in place. Use the proper size and type of screwdriver to remove the hard drive screws. Put all the screws in one place and label them.
c. Gently remove the hard drive from the case. Look for a jumper reference chart on the hard drive. If there is a jumper installed on the hard drive, use the jumper reference chart to see if the hard drive is set for a Master, Slave, or Cable Select (CS) drive. Place the hard drive in an antistatic bag.

Thumbscrew

These cases come with screws that you can tightened or loosen with your fingers. Loose the thumbscrews to remove the side panel. The thumbscrews are located on the edge of the computer case.
If you have a camera or smartphone, take a picture of the inside of the computer case to be used as a reference when reassembling the computer.

Questions:
What type of screwdriver did you use to remove the screws?

How many screws secured the side panels?

Step 3: Antistatic Wrist Strap.

Put on an antistatic wrist strap. Connect one end of the conductor to the wrist strap. Clip the other end of the conductor to an unpainted, metal part of the case.

If you have an antistatic mat, place it on the work surface and put the computer case on top of it. Ground the antistatic mat to an unpainted, metal part of the case.

Part 2: Parts Removal

In this part, you will remove the internal drives and data cables, adapter cards, memory modules, and power supply.

Note: Some manufacturers do not use screws to fasten components inside of the computer case. Some may use plastic or metal clips that fasten components to the computer chassis. When in doubt, perform a web search for manufacturer of the computer case or computer system.

Note: Be careful to remove only screws that are holding components in place, and not the screws that hold components together.

Step 1: Remove the Hard Drive.

a) Locate the hard drive. Carefully disconnect the power and data cables from the back of the hard drive.
b) Locate all the screws that secure the hard drive in place. Use the proper size and type of screwdriver to remove the hard drive screws. Put all the screws in one place and label them.

Question:
Which type of data cable did you disconnect?

Questions:
What type of screws secured the hard drive to the case?

How many screws secured the hard drive to the case?

Is the hard drive connected to a mounting bracket? If so, what type of screws secure the hard drive to the mounting bracket?

Caution: Do NOT remove the screws that hold the hard drive together.

c) Gently remove the hard drive from the case. Look for a jumper reference chart on the hard drive. If there is a jumper installed on the hard drive, use the jumper reference chart to see if the hard drive is set for a Master, Slave, or Cable Select (CS) drive. Place the hard drive in an antistatic bag.

What is the jumper setting of the hard drive?

Step 2: Remove Optical Drive.

a) Locate the optical drive (Blu-ray, DVD, etc.). Carefully disconnect the power and data cables from the optical drive. Remove the audio cable from the optical drive if there is one connected.

Questions:
What kind of data cable did you disconnect?

Is there a jumper on the optical drive? What is the jumper setting?

b) Locate and remove all the screws that secure the optical drive to the case. Put all the screws in one place and label them. Place the optical drive in an antistatic bag.

Question:
How many screws secured the optical drive to the case?

Step 3: Remove the Power Supply.

a) Locate the power supply. Find the power connection(s) to the motherboard.
b) Gently remove the power connection(s) from the motherboard.

Question:
How many pins are there in the motherboard connector?

c) Disconnect the power cables from any case fans.
d) Disconnect the power cable from the video card if it requires one.
e) Disconnect any other power supply cables from where they were connected.

Question:
If there were additional cables disconnected, to what were they connected?

f) Locate and remove all the screws that secure the power supply to the case. Put all the screws in one place and label them.

Question:
How many screws secure the power supply to the case?

g) Carefully remove the power supply from the case. Place the power supply with the other computer components.

Step 4: Remove Adapter Cards.

a) Locate any adapter cards that are installed in the computer, such as a video, NIC, or sound card.
b) Locate and remove the screw that secures the adapter card to the case. Put the adapter card screws in one place and label them.
c) Carefully remove the adapter card from the slot. Be sure to hold the adapter card by the mounting bracket or by the edges. Place the adapter card in an antistatic bag. Repeat this process for all the adapter cards.

Note: Be very careful when removing video adapters. There is often a locking tab on the slot that must be released before the card can be removed.

d) List the adapter cards and the slot types below.

Adapter Card	**Slot Type**

a. Locate the memory modules on the motherboard.
b. Remove the memory modules from the motherboard. Be sure to release any locking tabs that may be securing the memory module. Hold the memory module by the edges and gently lift out of the slot. Put the memory modules in an antistatic bag.

a. Remove all data cables from the motherboard. Make sure to note the connection location of any cable you disconnect.
b. You have completed this lab. The computer case should contain the motherboard, the CPU, and any cooling devices. Do not remove any additional components.

Step 5: Remove Memory Modules.

a) Locate the memory modules on the motherboard.

Questions:
What type of memory modules are installed on the motherboard?

How many memory modules are installed on the motherboard?

b) Remove the memory modules from the motherboard. Be sure to release any locking tabs that may be securing the memory module. Hold the memory module by the edges and gently lift out of the slot. Put the memory modules in an antistatic bag.

Step 6: Remove Data Cables.

a) Remove all data cables from the motherboard. Make sure to note the connection location of any cable you disconnect.

Question:
What types of cables were disconnected?

b) You have completed this lab. The computer case should contain the motherboard, the CPU, and any cooling devices. Do not remove any additional components.

1.4.1 Conclusion

1.4.1.1 Chapter 1: Introduction to Personal Computer Hardware

In the beginning of this chapter, you were introduced to the contents of a computer and the safety guidelines that can prevent electrical fires and injuries while working inside a computer. You also learned about ESD and how it can damage the computer equipment if not discharged properly.

Next, you learned about all the components that make up a PC starting with the case that houses all of the internal components. You learned about the various form factors of case and power supplies and how they have evolved over time. Next, the various types of connectors that are used to power various internal components such as the motherboard and storage drives, such as Serial AT Attachment (SATA), Molex, and PCIe were discussed as were the voltages provided by the connectors.

You also learned about motherboards, which is the backbone of the computer that contains buses, or electrical pathways, that connect electronic components. These components include the CPU, RAM, expansion slots, chipset, the BIOS and the UEFI chips.

Different types of storage devices such as hard disk drives, optical drives, and solid-state drives were also discussed along with the different versions of PATA and SATA interfaces that connect them to the motherboard.

The commonly used tools were explained, and the computer disassembly process was demonstrated. At the end of the chapter, you disassembled a computer as part of a hands-on lab.